HYDRAULIC EXCAVATOR

SHOP MANUAL model SK60

This is the shop manual for KOBELCO hydraulic excavator. Contained is the necessary technical data concerning the maintenance and repair of this model. The manual is divided into the following four major sections; GENERAL, SYSTEMS, COMPONENTS and PROCEDURE.

*GENERAL

LE01. SPECIFICATION
— OPERATION AND CONTROLS
LE03. LOCATION AND WEIGHT OF COMPONENTS
LE04. MAINTENANCE STANDARD AND TEST PROCEDURE
LE05. TROUBLE SHOOTING
— PREVENTIVE MAINTENANCE (Refer to Operators Manual)
LE07. WORKING STANDARD

*SYSTEMS

LE11. DRIVE SYSTEM
LE12. HYDRAULIC SYSTEM
LE15. SWING SYSTEM
LE18. TRAVEL SYSTEM
LE21. ATTACHMENTS
LE22. CONTROL SYSTEM
LE23. UPPER FRAME
LE25. ELECTRICAL SYSTEM
LE26. AIR-CONDITIONER SYSTEM
LE50. ENGINE

*COMPONENTS

12. HYDRAULIC PUMP
13. CONTROL VALVE
14. OTHER VALVES
15. HYDRAULIC MOTOR
16. SWIVEL JOINT
17. HYDRAULIC CYLINDER
21. REDUCTION UNIT

*PROCEDURE

When checking or repairing the machine we suggest that you refer to this manual carefully. We hope that reference to this manual will help to maintain a high level of working efficiency and reliability. For further details on maintenance and checks refer to the "OPERATORS MANUAL" which has been supplied with the machine.

Although all data was correct at the time of printing, due to continual design changes and improvements, some contents may not conform to the actual machine. Take special care to order parts only after confirming the validity of the parts number in the "PARTS MANUAL".

If you notice any explanatory discrepancies, after consulting one of our representatives, please update your manual according to the latest data. However, in the event of any specification changes, we will issue revised edition.

INDEX

KOBELCO

Book code No. S5LE0005E③

⚠ WARNING

SAFETY

⚠ WARNING

The proper and safe lubrication and maintenance for this machine, recommended by KOBELCO are outlined in the OPERATION & MAINTENANCE GUIDE for this machine.

Improper performance of lubrication or maintenance procedures is dangerous and could result in injury or death. Read and understand the OPERATION & MAINTENANCE GUIDE before performing any lubrication or maintenance.

The serviceman or mechanic may be unfamiliar with many of the systems on this machine. This makes it important to use caution when performing service work. A knowledge of the system and or components is important before the removal or disassembly of any component.

Because of the size of some of the machine components, the serviceman or mechanic should check the weights noted in this Manual. Use proper lifting procedures when removing any components.

Following is a list of basic precautions that should always be observed.

1. Read and understand all Warning plates and decals on the machine before operating, lubricating or repairing this product.
2. Always wear protective glasses and protective shoes when working around machines. In particular, wear protective glasses when pounding on any part of the machine or its attachments with a hammer or sledge. Use welders gloves, hood/goggles, apron and other protective clothing appropriate to the welding job being performed. Do not wear loose-fitting or torn clothing. Remove all rings from fingers when working on machinery.
3. Disconnect battery and discharge any capacitors before starting to work on machine. Hang "Do Not Operate" tag in the Operator's Compartment.
4. If possible, make all repairs with the machine parked on a level, hard surface. Block machine so it does not roll while working on or under machine.
5. Do not work on any machine that is supported only by lift jacks or a hoist. Always use blocks or jack stands to support the machine before performing any disassembly.

⚠ WARNING

Do not operate this machine unless you have read and understand the instructions in the OPERATOR'S MANUAL. Improper machine operation is dangerous and could result in injury or death.

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6. Relieve all pressure in air, oil or water systems before any lines, fittings or related items are disconnected or removed. Always make sure all raised components are blocked correctly and be alert for possible pressure when disconnecting any device from a system that utilizes pressure.
7. Lower the bucket, blade, ripper or other implements to the ground before performing any work on the machine. If this cannot be done, make sure the bucket, blade, ripper or other implement is blocked correctly to prevent it from dropping unexpectedly.
8. Use steps and grab handles when mounting or dismounting a machine. Clean any mud or debris from steps, walkways or work platforms before using. Always face machine when using steps, ladders and walkways. When it is not possible to use the designed access system, provide ladders, scaffolds, or work platforms to perform safe repair operations.
9. To avoid back injury, use a hoist when lifting components which weigh 23 kg (50 lbs) or more. Make sure all chains, hooks, slings, etc., are in good condition and are in the correct capacity. Be sure hooks are positioned correctly. Lifting eyes are not to be side loaded during a lifting operation.
10. To avoid burns, be alert for hot parts on machines which have just been stopped and hot fluids in lines, tubes and compartments.
11. Be careful when removing cover plates. Gradually back off the last two bolts or nuts located at opposite ends of the cover or device and pry cover loose to relieve any spring or other pressure, before removing the last two bolts or nuts completely.
12. Be careful when removing filler caps, breathers and plugs on the machine. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure. The danger is even greater if the machine has just been stopped because fluids can be hot.

⚠ WARNING

13. Always use tools that are in good condition and be sure you understand how to use them before performing any service work.

14. Reinstall all fasteners with same part number. Do not use a lesser quality fastener if replacements are necessary.

15. Repairs which require welding should be performed only with the benefit of the appropriate reference information and by personnel adequately trained and knowledgeable in welding procedures. Determine type of metal being welded and select correct welding procedure and electrodes, rods or wire to provide a weld metal strength equivalent at least to that of parent metal. Always disconnect battery during welding operations to protect sensitive electric equipment.

16. Do not damage wiring during removal operations. Reinstall the wiring so it is not damaged nor will it be damaged in operation by contacting sharp corners, or by rubbing against some object or hot surface. Do not connect wiring to a line containing fluid.

17. Be sure all protective devices including guards and shields are properly installed and functioning correctly before starting a repair. If a guard or shield must be removed to perform the repair work, use extra caution.

18. Loose or damaged fuel, lubricant and hydraulic lines, tubes and hoses can cause fires. Do not bend or strike high pressure lines or install ones which have been bent or damaged. Inspect lines, tubes and hoses carefully. Do not check for leaks with your hands. Pin hole (very small) leaks can result in a high velocity oil stream that will be invisible close to the hose. This oil can penetrate the skin and cause personal injury. Use cardboard or paper to locate pin hole leaks.

19. Tighten connections to the correct torque. Make sure that all heat shields, clamps and guards are installed correctly to avoid excessive heat, vibration or rubbing against other parts during operation. Shields that protect against oil spray onto hot exhaust components in event of a line, tube or seal failure must be installed correctly.

20. Do not operate a machine if any rotating part is damaged or contacts any other part during operation. Any high speed rotating component that has been damaged or altered should be checked for balance before reusing.

21. On track-type machines, be careful when servicing or separating tracks. Chips can fly when removing or installing a track pin. Wear safety glasses and long sleeve shirts. Track can unroll very quickly when separated. Keep away from front and rear of machine. The machine can move unexpectedly when both tracks are disengaged from the sprockets. Block the machine to prevent it from moving.

22. Caution should be used to avoid breathing dust that may be generated when handling components containing asbestos fibers. If this dust is inhaled, it can be hazardous to your health. Components in KOBELCO products that may contain asbestos fibers are brake pads, brake band and lining assemblies, clutch plates and some gaskets. The asbestos used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust which contains asbestos is not generated.

If dust which may contain asbestos is present, there are several common sense guidelines that should be followed.

a. Never use compressed air for cleaning.
b. Avoid brushing or grinding of asbestos containing materials.
c. For clean up, use wet methods or a vacuum equipped with a high efficiency particulate air (HEPA) filter.
d. Use exhaust ventilation on permanent machining jobs.
e. Wear an approved respirator if there is no other way to control the dust.
f. Comply with applicable rules and regulations for the work place.
g. Follow environmental rules and regulations for disposal of asbestos.
h. Avoid areas where asbestos particles may be in the air.

SHOP MANUAL

model SK60

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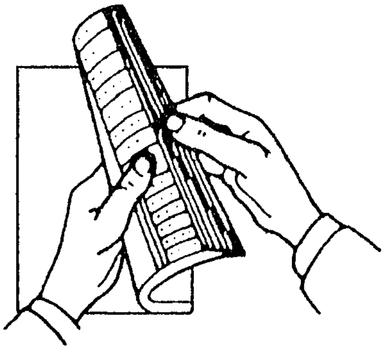
○How to Index each Shop Manual Section
The GENERAL of this shop manual consists of 7 headings as shown above. Each section can be easily referred to by indexes appended to the margin of the page as indicated on the right. Please use the indexes for speedy reference.



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GENERAL

SK60 List of Shop Manual GENERAL Section

Index No.	Title	Book Code No. Distribution Year - Month		
LE01	SPECIFICATION	S5LE0105E② 1991-12		
—	OPERATION	S2LE1015E② Refer to Operators manual		
LE03	LOCATION AND WEIGHT OF COMPONENTS	S5LE0305E① 1990-11		
LE04	MAINTENANCE STANDARDS AND TEST PROCEDURES	S5LE0406E 1990-10		
LE05	TROUBLESHOOTING	S5LE0505E① 1993-2		
—	PREVENTIVE MAINTENANCE	S2LE1015E② Refer to Operators manual		
LE07	WORKING STANDARDS	S5LE0702E 1990-6		
	Applicable Machines	LE-11001~		

BooK code No. S5LE0105E②

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SHOP MANUAL SK60

LE01

SPECIFICATION

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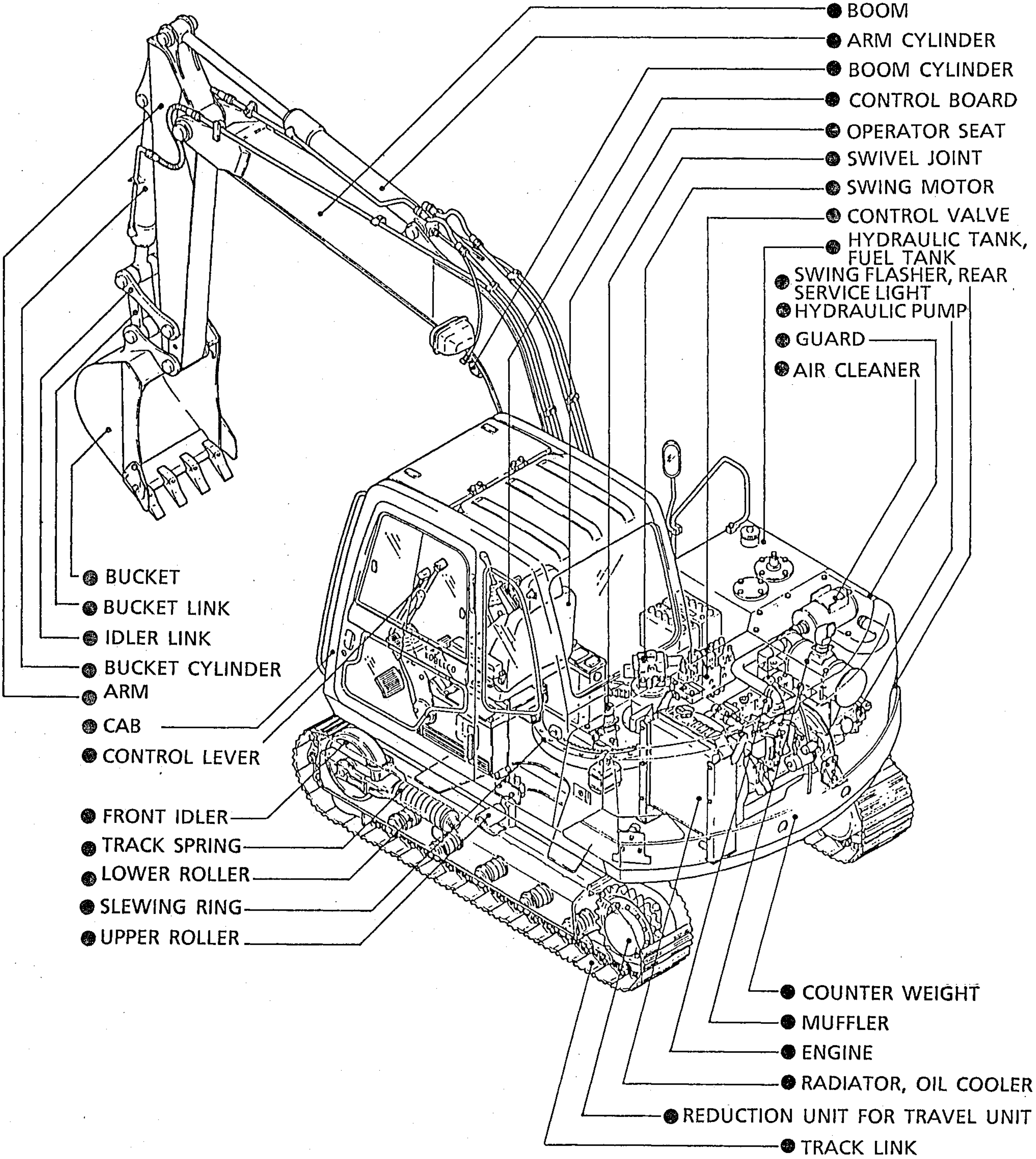
KOBE STEEL, LTD.

Applicable Machines
LE-11001~

Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE0105E K
First revision	Novenber, 1990	S5LE0105E① K
Second revision	December, 1991	S5LE0105E② K

1. LOCATION OF COMPONENTS

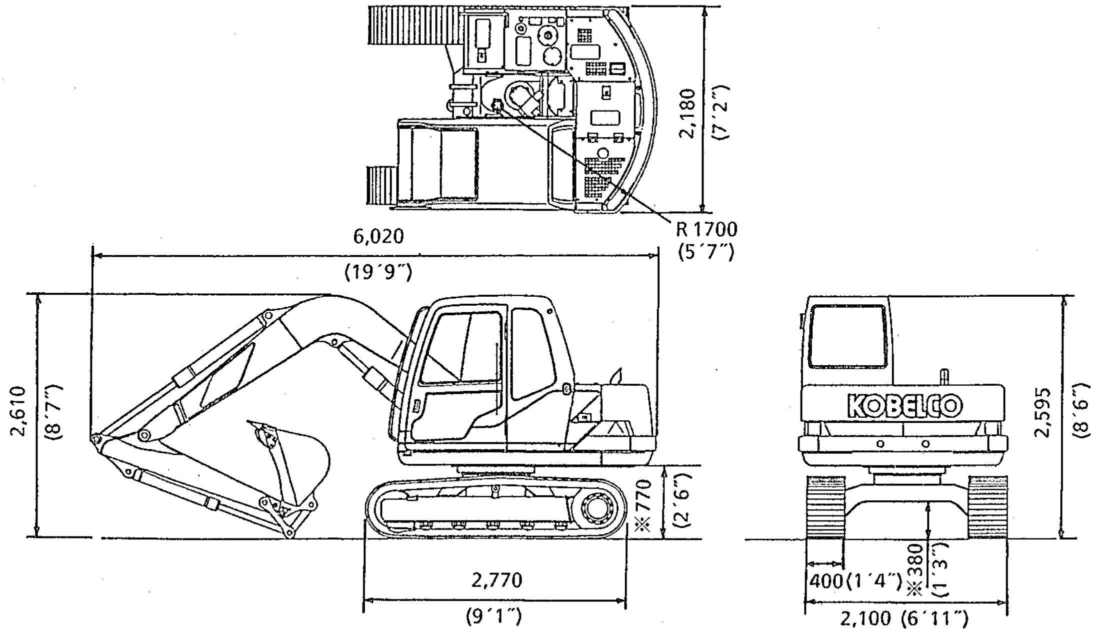


● BOOM
● ARM CYLINDER
● BOOM CYLINDER
● CONTROL BOARD
● OPERATOR SEAT
● SWIVEL JOINT
● SWING MOTOR
● CONTROL VALVE
● HYDRAULIC TANK, FUEL TANK
● SWING FLASHER, REAR SERVICE LIGHT
● HYDRAULIC PUMP
● GUARD
● AIR CLEANER
● BUCKET
● BUCKET LINK
● IDLER LINK
● BUCKET CYLINDER
● ARM
● CAB
● CONTROL LEVER
● FRONT IDLER
● TRACK SPRING
● LOWER ROLLER
● SLEWING RING
● UPPER ROLLER
● COUNTER WEIGHT
● MUFFLER
● ENGINE
● RADIATOR, OIL COOLER
● REDUCTION UNIT FOR TRAVEL UNIT
● TRACK LINK
KOBELCO

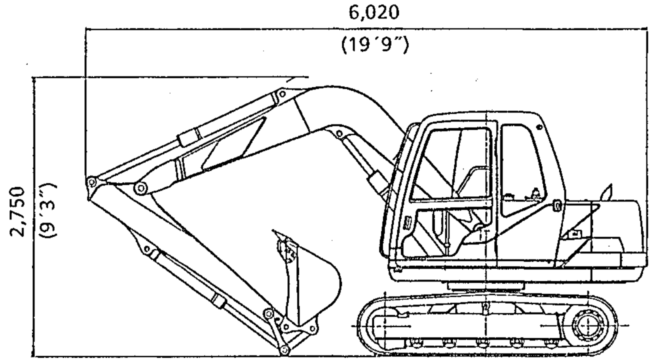
2. GENERAL DIMENSIONS

▨3.7m (12ft2 in) BOOM + 1.73m (5ft 8 in) ARM-ATTACHED STANDARD MACHINE

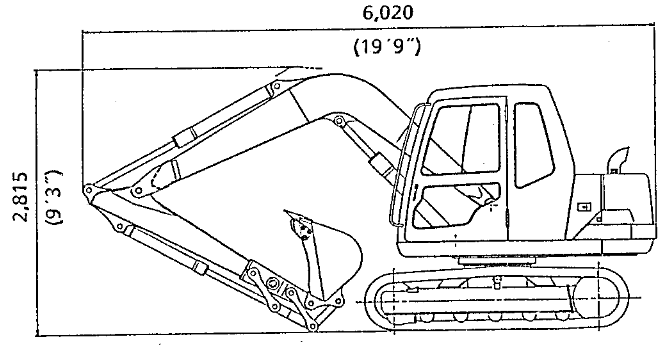
Unit : mm 〔 ft-in 〕


2,180
(7'2")
R 1700
(5'7")
6,020
(19'9")
2,610
(8'7")
※770
(2'6")
2,770
(9'1")
KOBELCO
2,595
(8'6")
400(1'4")
※380
(1'3")
2,100 (6'11")

▨WITH 3.7m (12ft2 in) BOOM + 2.15m (7ft 1in) ARM)


6,020
(19'9")
2,750
(9'3")

▨3.7m (12ft2 in) BOOM + 1.73m (5ft 8 in) + 0.45m (1ft 6 in) EXTENSION ARM


6,020
(19'9")
2,815
(9'3")

☞ The figures marked ※ in the illustration do not include the shoe embossment (20mm) 〔 0.78" 〕 .

3. SPECIFICATIONS AND PERFORMANCE

■ SPEED AND CLIMBING ABILITY

Swing speed	13rpm
Travel speed	2-SPEED 5.5 km/h (3.4 MPH) · 1-SPEED 3.7 km/h (2.3 MPH)
Gradeabilicy	35° (70%)

■ ENGINE

Model		ISUZU 4JB1
Type		Water-cooled 4-cycle, direct injection type
Number of cylinder-Bore x Stroke		4-93mm(3.66in) x 102mm(4.02in)
Total displacement		2,771c.c. (169cuin)
Rated output power/revolution	JISD1005 Net	57ps/2,200rpm
	SAEJ1349 Net	40.7kw/2,200rpm
	DIN 6270 Net	39.8kw/2,200rpm
Maximum torque/revolution	JISD1005 Net	18kgf·m / 1,800rpm
	SAEJ1349 Net	171.6N·m / 1,800rpm
	DIN 6270 Net	167.5N·m / 1,800rpm

■ HYDRAULIC COMPONENTS

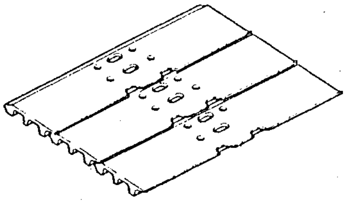
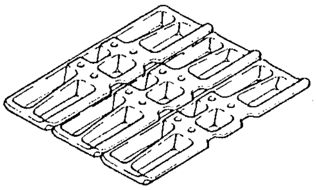
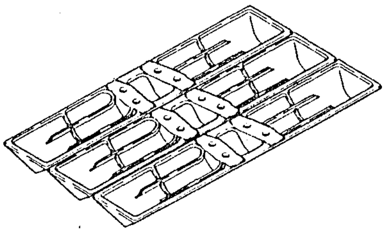
Hydraulic pump	Double-pump variable displacement, axial piston + gear pump
Hydraulic motor (swing)	Axial piston motor
Hydraulic motor (travel)	Axial piston motor
Control valve	5-section multiple control valve + 1-section control valve (swing)
Cylinders (boom, arm, and bucket)	Double acting cylinder
Return filter	Safety valve containing filter type
Oil cooler	Air-cooled type

■ WEIGHT

Unit : kg (lbs)

Fully-equipped weight	6,400 (14,100)	6,670 (14,700)
Upper machinery	3,170 (7,000)	←
Lower machinery (with 400mm(16″) grocer shoe)	2,190 (4,800)	–
(with 600mm(24″) grocer shoe)	–	2,460 (5,400)
Attachment (3.7(12ft 2in) boom + 1.73m(5ft 8in) arm + 0.25m^3 (0.33cu yd) bucket)	1,040 (2,300)	←

4. TYPE OF SHOES

Shape	Width of track shoe (mm(ft-in))	Overall width of crawler (mm(ft-in))	Ground contact Pressure kgf/cm² (psi)		
			S.T.D Arm 1.73m (5′8″)	2.15m (7′1″) Arm	1.73m (5′8″) + EXT.
Grouser(equal height) 	400(16″)	2,100(6′11″)	0.34(4.83)	0.34(4.83)	0.34(4.83)
	500(20″)	2,200(7′ 3″)	0.27(3.83)	0.27(3.83)	0.28(3.98)
	600(24″)	2,300(7′ 7″)	0.23(3.27)	0.23(3.27)	0.23(3.27)
Flat 	400(16″)	2,100(6′11″)	0.34(4.83)	0.34(4.83)	0.35(4.98)
Triangle 	600(24″)	2,300(7′ 7″)	0.23(3.27)	0.23(3.27)	0.23(3.27)
	700(27″)	2,400(7′10″)	0.20(2.84)	0.20(2.84)	0.20(2.84)

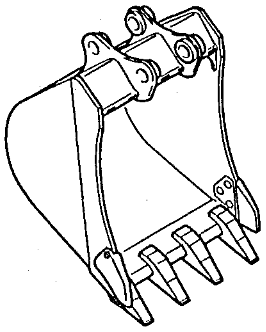
☞ ◎400mm (16″) · 500mm (20″) · 600mm (24″) shoes, flat shoes and 600mm (24″) · 700mm (27″) triangle shoes come in three types, wet land, paved road and soft land. Do not use them at sites with many stones and gravels in any circumstances.

◎Note that if you operate such shoe-mounted machines in general civil construction work and in a dry riverbed, it will cause shoes to bend, bring about slackening of shoe bolts and damage to under frame parts (links, crawlers, etc.).

5. TYPE AND COMBINATION OF ATTACHMENTS

■TYPES OF BUCKETS

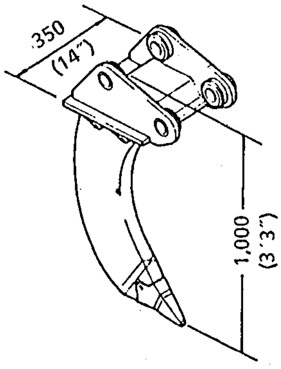
HOE BUCKET



Heaped capacity m³ (cuyd)	Outside width of bucket mm (ft-in)		No. of teeth	Presence or not of side cutter	Possibility of turnover	Weight kg (lbs)
	With side cutter	With out side cutter				
0.1(0.13)	——	368(1′2″)	3	No	Yes	160(350)
0.16(0.21)	560(1′10″)	460(1′6″)	3	Yes	Yes	170(370)
0.2(0.26)	650(2′2″)	550(1′10″)	3	Yes	Yes	180(400)
0.25(0.33)	770(2′6″)	670(2′2″)	4	Yes	Yes	210(460)
0.3(0.39)	——	820(2′8″)	4	No	Yes	220(490)

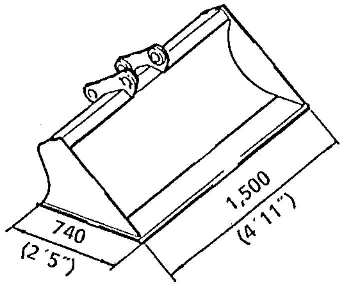
RIPPER

Turnover not possible
Weight: 210kg (460 lbs)



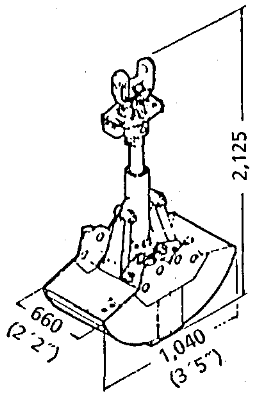
SLOPE FINISHING BUCKET

Turnover not possible
Capacity: 0.2m³ (0.26 cuyd)
Weight: 300kg (660 lbs)



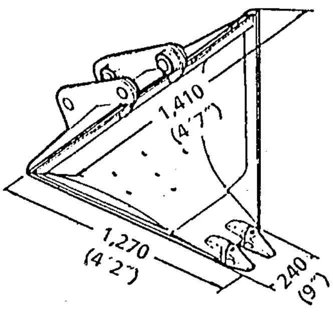
CLAMSHELL BUCKET

Capacity: 0.2m³ (0.26 cuyd)
Weight: 435kg (960 lbs)
Width of opening:
1,240mm (4ft1in)



V-BUCKET

Turnover not possible
Capacity: 0.2m³ (0.26 cuyd)
Weight: 180kg (400 lbs)



▨COMBINATIONS OF ATTACHMENTS

Bucket				Applicable arm		
Type	JIS heaped capacity m^3(cu yd)	SAE heaped capacity m^3(cu yd)	JIS·SAE struck capacity m^3(cu yd)	1.73m (5ft8in) arm	2.15m (7ft1in) arm	1.73m (5ft8in) arm + 0.45 m (1ft6in) extension arm
Hoe bucket	0.1 (0.13)	0.11 (0.14)	0.09 (0.12)	○	○	○
	0.16 (0.21)	0.18 (0.24)	0.14 (0.18)	○	○	○
	0.2 (0.26)	0.23 (0.3)	0.17 (0.22)	○	◎	◎
	0.25 (0.33)	0.28 (0.37)	0.22 (0.29)	◎	△	△
	0.3 (0.39)	0.34 (0.44)	0.26 (0.34)	△	×	×
Clamshell bucket	0.2 (0.26)	—	—	○	○	×
Slope finishing bucket	Width × depth 0.74m × 1.5m (2ft5in × 4ft11in)	—	—	△	△	△
Ripper	—	—	—	○	×	×
V-bucket	0.2 (0.26)	0.23 (0.3)	0.17 (0.22)	△	△	△
Bucket with ejector	0.1 (0.13)	0.11 (1.14)	0.09 (0.12)	○	○	○

☞ ◎ Standard combinations

○ General operation :	Digging and loading of sand, gravels and clay-mixed soil
△ Light operation :	Operations mainly consisting of loading of loose sand and soil (for instance, operations in paddy fields and loading of sand and gravels)
× Not usable :	Do not operate in such combinations as guarantee does not cover them.

⚠ ◎If a bucket other than hoe buckets is used to execute turnover operation, it will cause damage to the arm and the bucket.

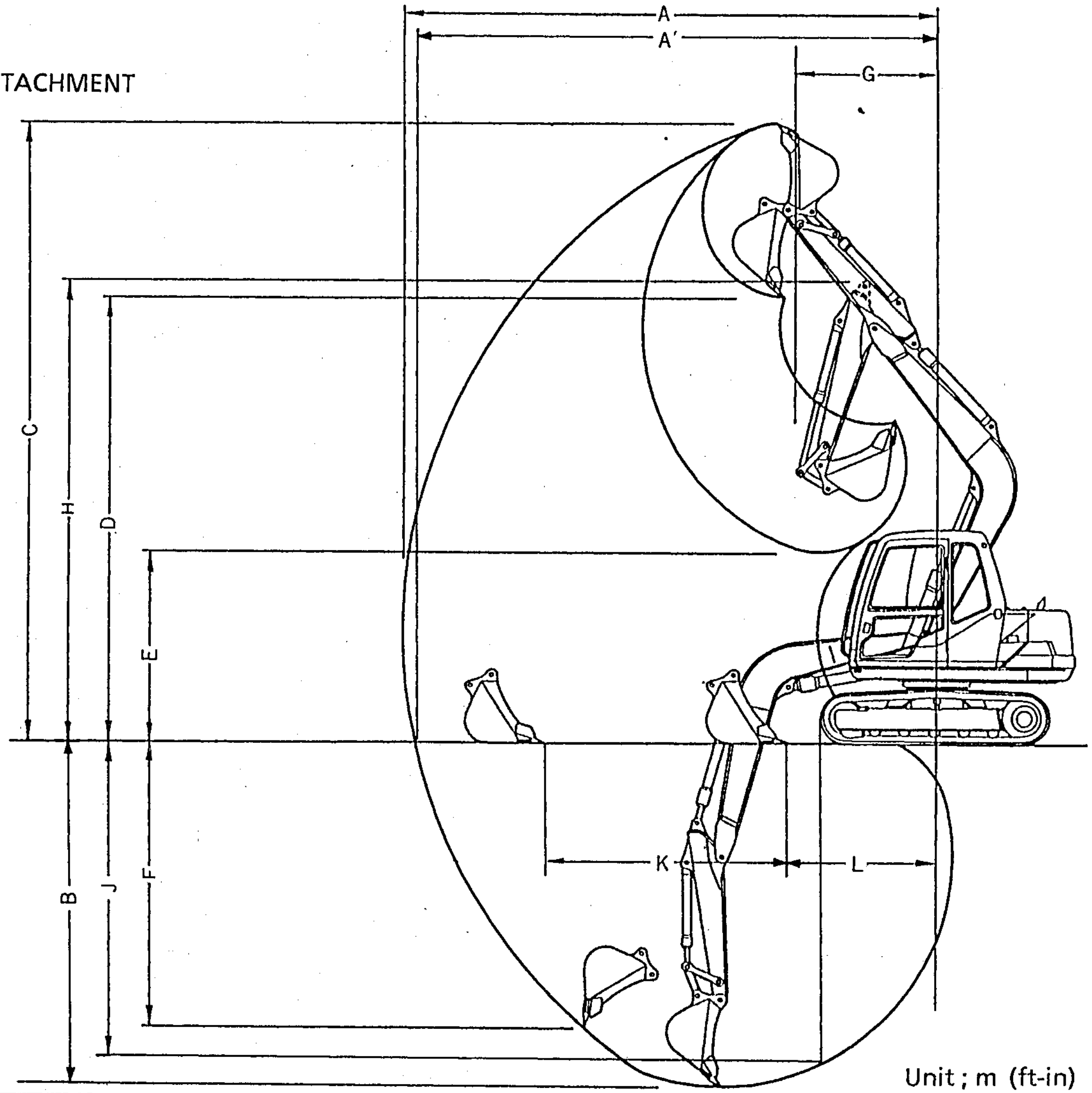
◎The combinations other than those mentioned in the above table can not be used in principle. For details, contact us.

▨DIGGING FORCE

Arm + Bucket	Digging force ton (UK ton)	
	Arm	Bucket
1.73m + 0.25m3 (5 ft 8 in + 0.33 cuyd)	3.7 (3.6)	4.8 (4.7)
2.15m + 0.2m3 (7 ft 1 in + 0.26 cuyd)	3.2 (3.1)	4.8 (4.7)
1.73m + 0.45m EXT. + 0.2m3 (5 ft 8 in + 1 ft 6 in + 0.26 cuyd)	3.2 (3.1)	4.8 (4.7)

6. WORKING RANGES OF ATTACHMENTS

■BACKHOE ATTACHMENT

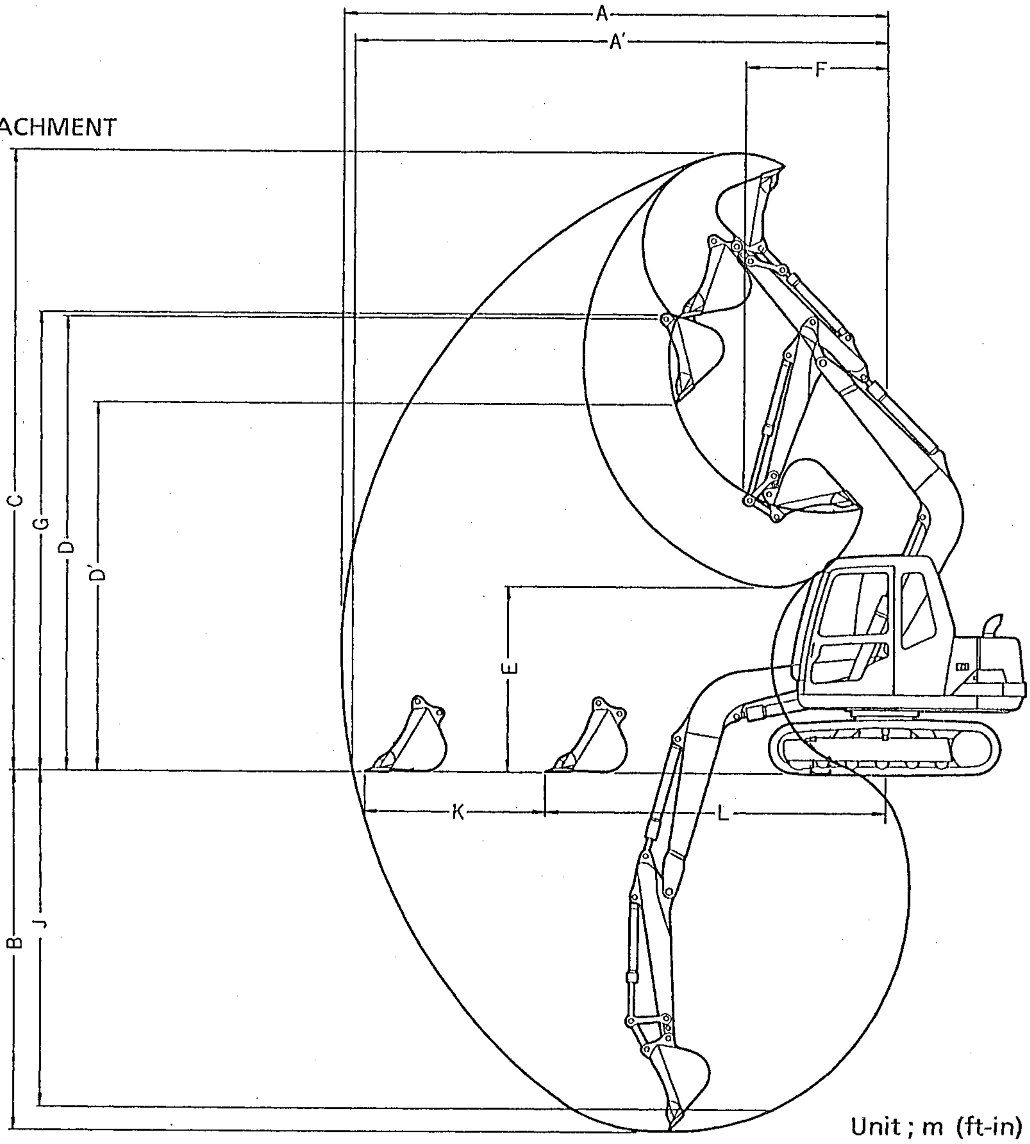


Unit ; m (ft-in)

Item	Range	Type of attachment	1.73m (5ft8in) arm with $0.25m^3$ (0.33cuyd) bucket	2.15m (7ft1in) arm with $0.2m^3$ (0.26cuyd) bucket	1.73m (5ft8in) arm + 0.45m (1ft6in) arm extension arm with $0.2m^3$ (0.26cuyd) bucket
A	Max digging reach		6.42(21′ 1″)	6.81(22′ 4″)	6.82(22′ 4″)
A′	Max. reach at ground level		6.28(20′ 7″)	6.68(21′11″)	6.70(22′)
B	Max. digging depth		4.20(13′ 9″)	4.60(15′ 1″)	4.63(15′ 2″)
C	Max. digging height		7.36(24′ 2″)	7.69(25′ 3″)	7.68(25′ 2″)
D	Max. dumping clearance		5.29(17′ 4″)	5.62(18′ 5″)	5.61(18′ 5″)
E	Min. dumping clearance		2.29(7′ 6″)	1.87(6′ 2″)	1.86(6′ 1″)
F	Max. vertical digging depth		3.47(11′ 5″)	3.85(12′ 8″)	3.78(12′ 5″)
G	Min swing radius		1.70(5′ 7″)	1.74(5′ 9″)	1.81(5′11″)
H	Height at min. swing radius		5.51(18′ 1″)	5.50(18′ 1″)	5.51(18′ 1″)
J	Digging depth at 8ft-flat floor		3.85(12′ 8″)	4.33(14′ 2″)	4.37(14′ 4″)
K	Horizontal digging distance	Stroke	2.92(9′ 7″)	3.63(11′11″)	3.61(11′10″)
L		At min.	1.79(5′10″)	1.48(4′10″)	1.52(5′)

☞ The figures in this table do not include the projection of shoes 〔20mm (0.78in)〕.

▩FACE SHOVEL ATTACHMENT



Unit ; m (ft-in)

Item Range / Type of attachment			1.73m (5ft8in) arm with 0.25m³ (0.33cuyd) bucket	2.15m (7ft1in) arm with 0.2m³ (0.26cuyd) bucket	1.73m (5ft8in) arm + 0.45m (1ft6in) arm extension arm with 0.2m³ (0.26cuyd) bucket
A	Max digging reach		6.51(21′ 4″)	6.91(22′ 8″)	6.92(22′ 8″)
A'	Max. reach at ground level		6.37(20′11″)	6.78(22′ 3″)	6.79(22′ 3″)
B	Max. digging depth		4.30(14′ 1″)	4.70(15′ 5″)	4.72(15′ 6″)
C	Max. digging height		7.46(24′ 6″)	7.80(25′ 7″)	7.79(25′ 7″)
D	Max. dumping clearance		5.46(17′11″)	5.79(19′)	5.79(19′)
D'	Max. dumping clearance (45°)		4.42(14′ 6″)	4.58(15′)	4.53(14′10″)
E	Min. dumping clearance		2.20(7′ 3″)	1.77(5′10″)	1.76(5′ 9″)
F	Min swing radius		1.70(5′ 7″)	1.74(5′ 9″)	1.81(5′11″)
G	Height at min. swing radius		5.51(18′ 1″)	5.50(18′)	5.51(18′ 1″)
J	Digging depth at 8ft-flat floor		3.98(13′ 1″)	4.43(14′ 6″)	4.47(14′ 8″)
K	Horizontal digging discance	Stroke	2.16(7′ 1″)	2.82(9′ 3″)	2.90(9′ 6″)
L		At min.	4.07(13′ 4″)	3.82(12′ 6″)	3.75(12′ 4″)

☞ The figures in this table do not include the projection of shoes (20mm (0.78in)) .

7. LIFTING-UP ABILITY DIAGRAM

(1) Calculation condition

The lifting-up ability of this drawing is indicated by metric standard. The indicated figures fall within 87% of a set pressure of the main relief valve used in the arm and the boom cylinder and 75% of static tilting load.

1) The load point is the fulcrum of the bucket and the bucket position is an embraced posture.
2) The figures on the upper stage indicate the lifting-up abillty of a machine facing sideways, while the figures at the bottom stage repressent a machine facing longitudinally.
3) Unit : ton Shoe width : 400mm (16″) shoe or 600mm (24″) shoe

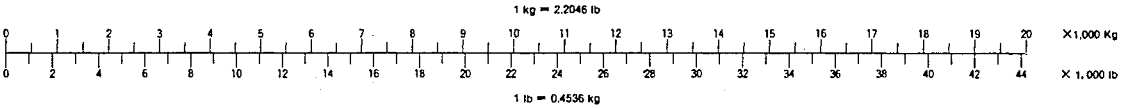
Calculation condition for U.K.

The lifting-up ability of this drawing is indicated by metric standard.

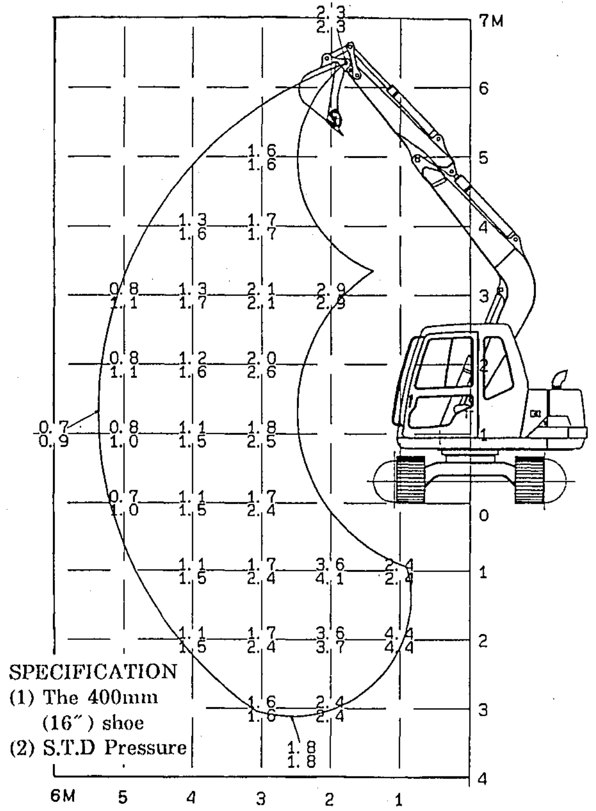
The indicated figures fall within 87% of a set pressure of the main relief valve used in the arm and the boom cylinder and 71% of static tilting load.

(2) Lifting-up ability diagram Item No. table

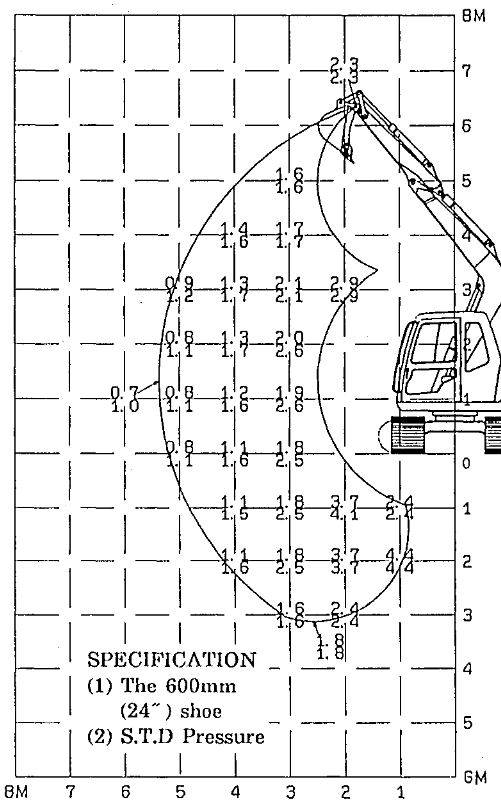
Model	Shoe width	Arm length (M) + bucket capacity (M³)				
		1.73M + 0.25M³ (5′8″) + (0.33cu · yd) STD	2.15M + 0.2M³ (7′1″) + (0.26cu · yd) LONG	For U.K	1.73M + EXT + 0.2M³ (5′8″) + EXT + (0.26cu·yd)	Short Loader + 0.3M³ Short Loader + (0.39cu·yd)
SK60	400mm (16″)	Reference No. 1	3	-	7	9
	600mm (24″)	2	4	6	8	10

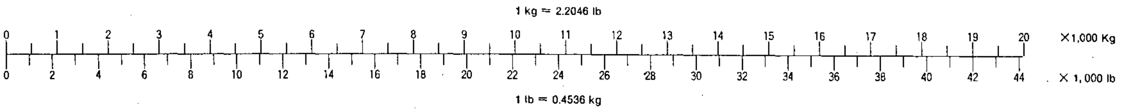

1 kg = 2.2046 lb
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 ×1,000 Kg
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 × 1,000 lb
1 lb = 0.4536 kg

(1) Unit ton

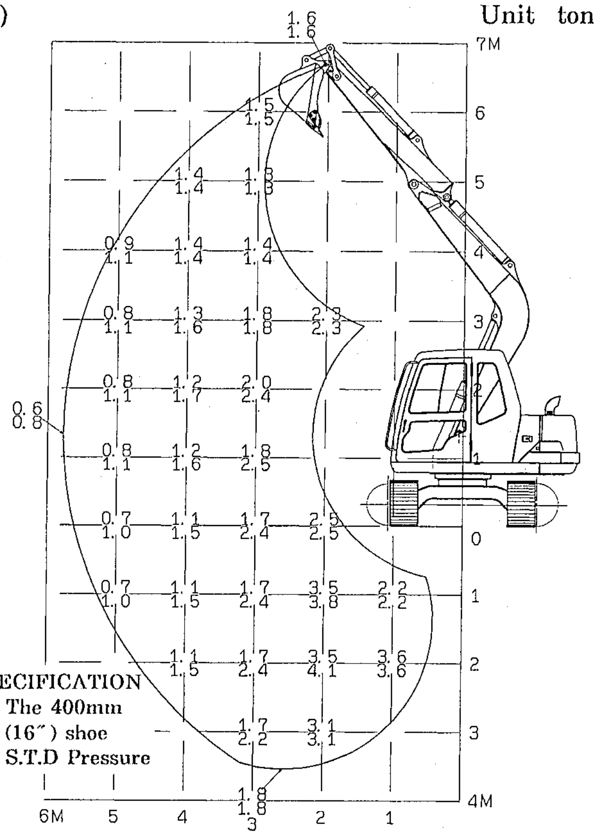


(2) Unit ton



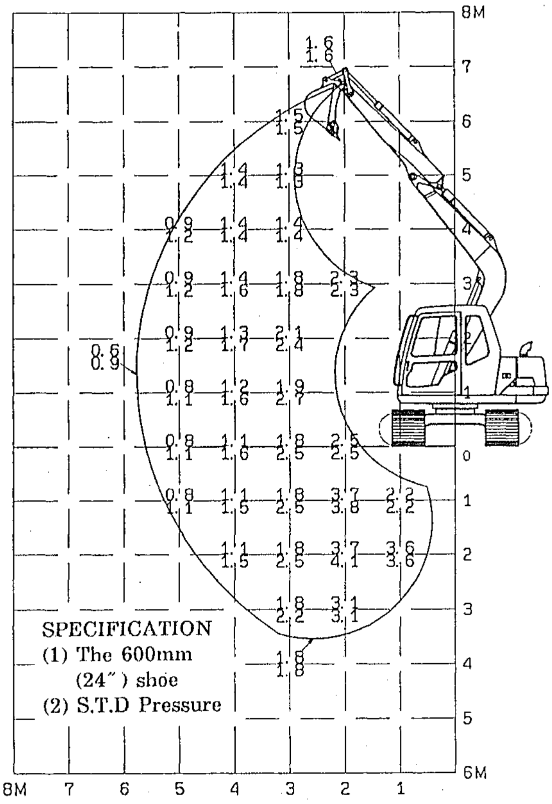

1 kg = 2.2046 lb
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 ×1,000 Kg
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 × 1,000 lb
1 lb = 0.4536 kg

(3) Unit ton



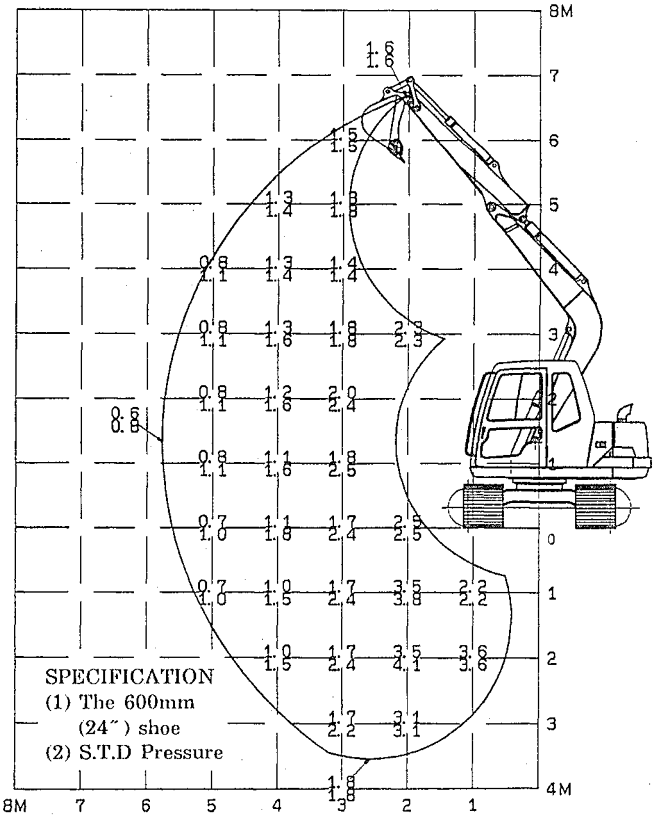
SPECIFICATION
(1) The 400mm
(16″) shoe
(2) S.T.D Pressure

(4) Unit ton

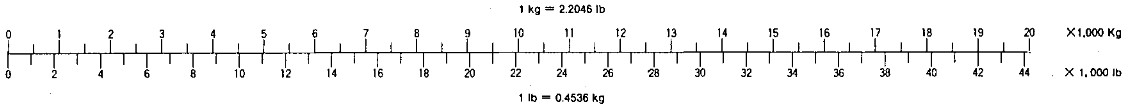


SPECIFICATION
(1) The 600mm
(24″) shoe
(2) S.T.D Pressure

(6) Unit ton

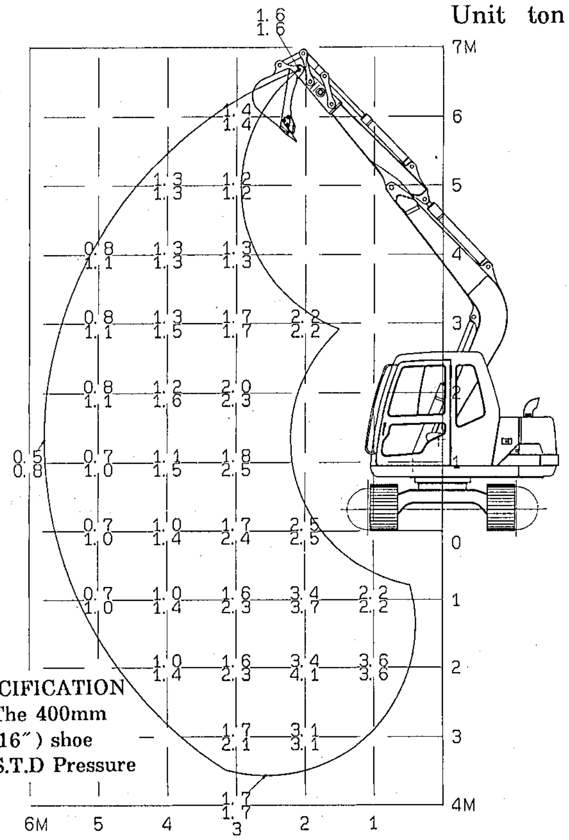


SPECIFICATION
(1) The 600mm
(24″) shoe
(2) S.T.D Pressure


1 kg = 2.2046 lb
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 X1,000 Kg
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 X 1,000 lb
1 lb = 0.4536 kg

(7)

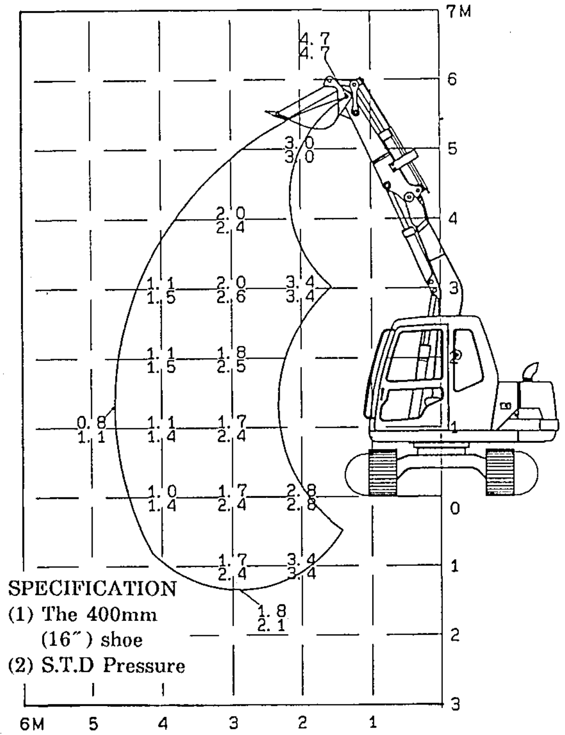
Unit ton



SPECIFICATION
(1) The 400mm
(16″) shoe
(2) S.T.D Pressure

(9)

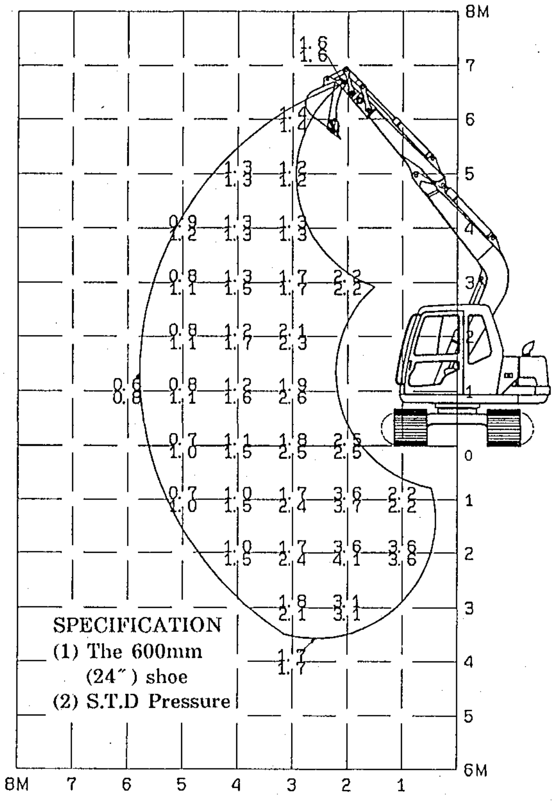
Unit ton



SPECIFICATION
(1) The 400mm
(16″) shoe
(2) S.T.D Pressure

(8)

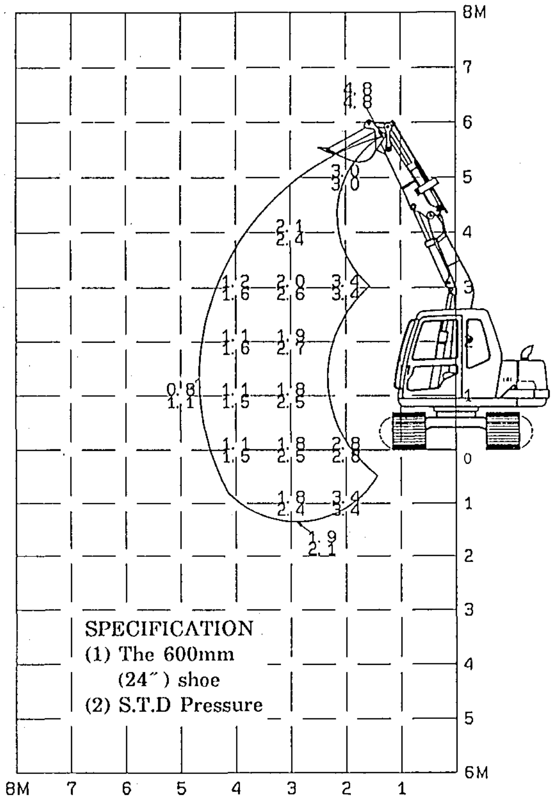
Unit ton



SPECIFICATION
(1) The 600mm
(24″) shoe
(2) S.T.D Pressure

(10)

Unit ton



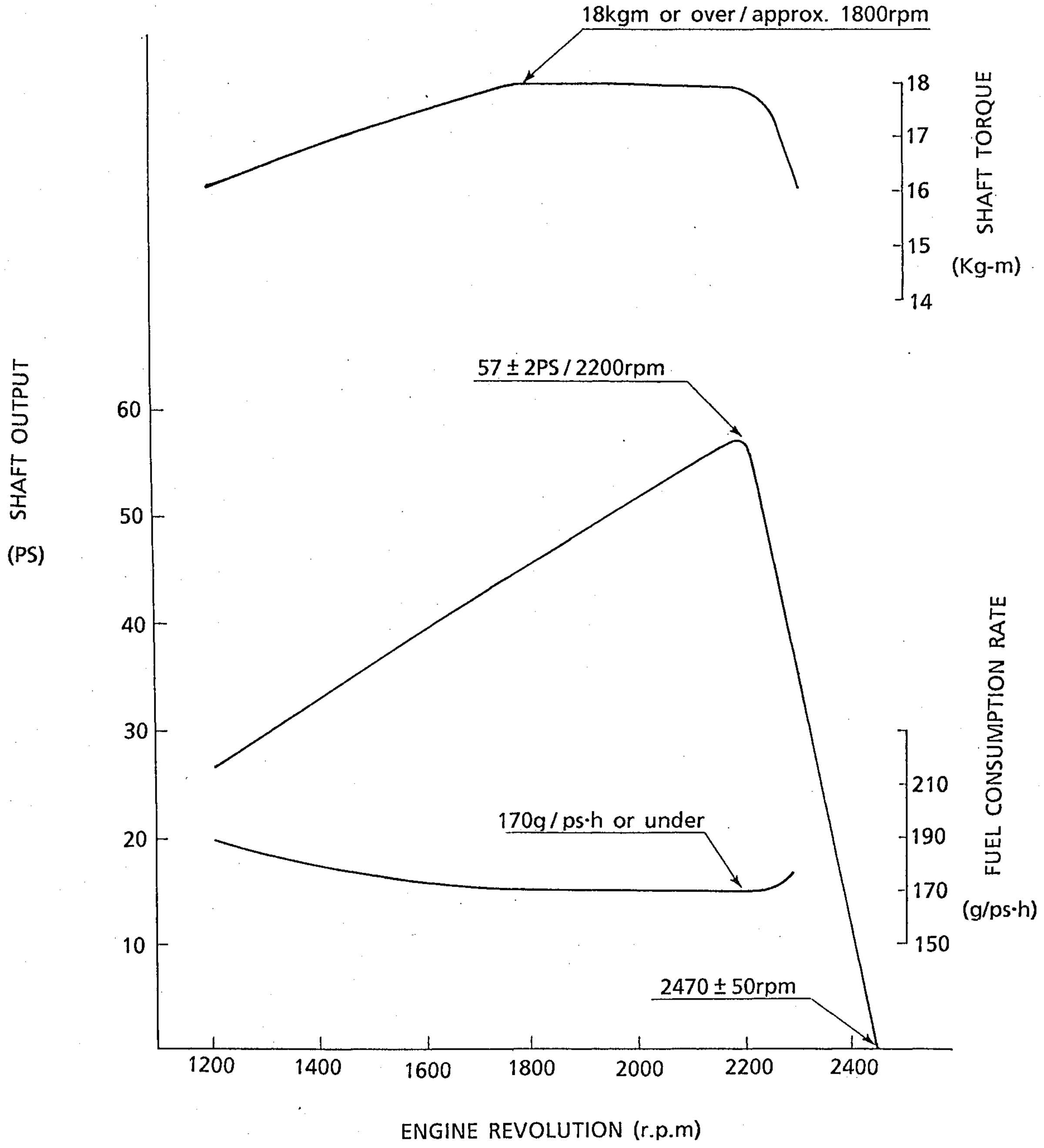
SPECIFICATION
(1) The 600mm
(24″) shoe
(2) S.T.D Pressure

8. ENGINE SPECIFICATIONS

MAJOR SPECIFCATIONS

<table>
<tr><th colspan="2"></th><th colspan="3">SK60</th></tr>
<tr><td colspan="2">Type</td><td colspan="3">Isuzu Motors Limited 4JB1</td></tr>
<tr><td colspan="2">No. of sylinders-Dir×Stroke</td><td colspan="3">6-93mm×102mm (3.66 in×4.02 in)</td></tr>
<tr><td colspan="2">Total displacement</td><td colspan="3">2,771cc (169 cuin)</td></tr>
<tr><td colspan="2">Compression ration</td><td colspan="3">18.2</td></tr>
<tr><td colspan="2">Output rating</td><td colspan="3">57PS / 2,200 rpm (40.7kw/ 2,200 rpm)</td></tr>
<tr><td colspan="2">Max. torque</td><td colspan="3">18kgf · m / 1,800 rpm (171.6 N – m / 1,800 rpm)</td></tr>
<tr><td colspan="2">High idling</td><td colspan="3">2,470±50 rpm</td></tr>
<tr><td colspan="2">Low idling</td><td colspan="3">850±25 rpm</td></tr>
<tr><td colspan="2">Injection start pressure</td><td colspan="3">185kgf / cm^2 (2,630psi)</td></tr>
<tr><td colspan="2">Thermostat</td><td colspan="3">Before top-dead center 82°C (180°F) Full open 95°C (203°F)</td></tr>
<tr><td colspan="2">Ignition order</td><td colspan="3">1-3-4-2</td></tr>
<tr><td colspan="2">Compression pressure</td><td colspan="3">30kgf / cm^2 (427psi) [at 200 rpm]</td></tr>
<tr><td colspan="2">Lube oil pressure</td><td colspan="3">–</td></tr>
<tr><td colspan="2">Fuel injection timing</td><td colspan="3">17°C before the top dead point</td></tr>
<tr><td rowspan="3">Valve clearance, valve action timing</td><td></td><td>Valve clearance</td><td>Open</td><td>Close</td></tr>
<tr><td>Suction valve</td><td>In cold state, in cold condition 0.4mm (0.016")</td><td>24.5° before the top dead point</td><td>55.5° before the bottom dead point</td></tr>
<tr><td>Exhaust valve</td><td>In cold state, in cold condition 0.4mm (0.016")</td><td>54° before the bottom dead point</td><td>26° before the top dead point</td></tr>
<tr><td colspan="2">Starter capacity</td><td colspan="3">3.2kw</td></tr>
<tr><td colspan="2">Generator capacity</td><td colspan="3">24V (20A)</td></tr>
<tr><td colspan="2">Cooling fan drive method</td><td colspan="3">Ø450 (Ø18in)suction type
Belt drive pulley ratio=Crank / Fan=1.117</td></tr>
<tr><td colspan="2">Engine oil volume</td><td colspan="3">Engine body 7±1ℓ (1.85±0.26 gal)</td></tr>
<tr><td colspan="2">Dry weight</td><td colspan="3">237kg (522 lbs)</td></tr>
<tr><td colspan="2">Fuel consumption ratio (rated point)</td><td colspan="3">170g (0.375 lbs) / PS · h</td></tr>
<tr><td colspan="2">Allowable inclination angle</td><td colspan="3">Front · Rear · Left · Right 35°</td></tr>
<tr><td colspan="2">Engine dimension (total length×total width×total height)</td><td colspan="3">751mm×610mm×781mm (30in×24in×31in)</td></tr>
<tr><td colspan="2">Rotating direction</td><td colspan="3">Clockwise as seen from the fan side</td></tr>
</table>

ENGINE CHARACTERISTIC CURVE
(ISUZU 4JB1)



BooK code No. S5LE0305E①

KOBELCO

SHOP MANUAL SK60

LOCATION AND WEIGHT OF COMPONENTS

LE03

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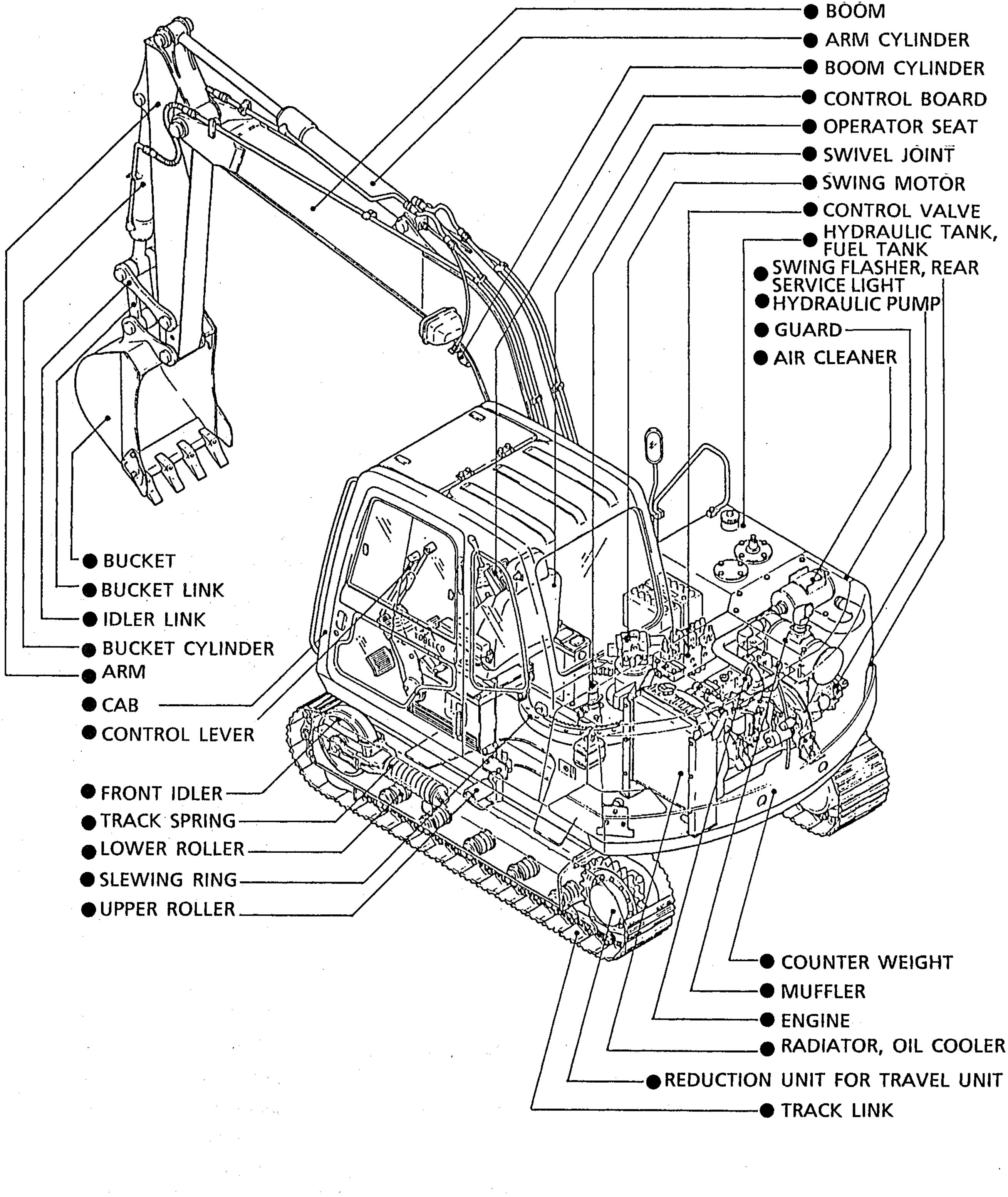
2. WEIGHT OF COMPONENTS ··························· 2
3. TRANSPORTATION WEIGHT ·························· 3

KOBE STEEL, LTD.

Applicable Machines
LE-11001~

Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE0305E K
First revision	November, 1990	S5LE0305E① K

1. LOCATION OF COMPONENTS


● BOOM
● ARM CYLINDER
● BOOM CYLINDER
● CONTROL BOARD
● OPERATOR SEAT
● SWIVEL JOINT
● SWING MOTOR
● CONTROL VALVE
● HYDRAULIC TANK, FUEL TANK
● SWING FLASHER, REAR SERVICE LIGHT
● HYDRAULIC PUMP
● GUARD
● AIR CLEANER
● BUCKET
● BUCKET LINK
● IDLER LINK
● BUCKET CYLINDER
● ARM
● CAB
● CONTROL LEVER
● FRONT IDLER
● TRACK SPRING
● LOWER ROLLER
● SLEWING RING
● UPPER ROLLER
● COUNTER WEIGHT
● MUFFLER
● ENGINE
● RADIATOR, OIL COOLER
● REDUCTION UNIT FOR TRAVEL UNIT
● TRACK LINK

2. WEIGHT OF COMPONENTS

Unit : kg (lbs)

Item		Model	SK60	
Complete Machine [std Export 400mm (16″) shoe]			6,400(14,100)	–
	[std Export 600mm (24″) shoe]		–	6,670(14,700)
1.	Upper Frame Assy (incl. 1.1~1.8)		3,170(7,000)	←
1.1	· Counter-weight		750(1,650)	←
1.2	· Cab		250(550)	←
1.3	· Boom cylinder	※	120(260)	←
1.4	· Engine, radiator	※	270(600)	←
1.5	· Pump assy		53(115)	←
1.6	· Control valve		67(150)	←
1.7	· Fuel and Hydraulic tank	※	145(320)	←
1.8	· Swing motor & reduction unit		110(240)	←
2.	Lower frame assy (incl. 2.1~2.9)		2,190(4,800)	2,470(5,450)
2.1	· Slwing ring		107(240)	←
2.2	· Travel motor & reduction unit		90 x 2(200 x 2)	←
2.3	· Idler assy		40 x 2(88 x 2)	←
2.4	· Lower roller assy		14 x 2(30 x 2)	←
2.5	· Upper roller assy		4.5 x 2(10 x 10)	←
2.6	· Track tension assy		26 x 2(57 x 2)	←
2.7	· Sprocket		28 x 2(62 x 2)	←
2.8	· Swivel joint		18(40)	←
2.9	· Track link with 400mm (16″) shoe assy		760(1670)	–
	· Track link with 500mm (20″) shoe assy		880(1940)	–
	· Track link with 600mm (24″) shoe assy		–	1,040(2,290)
2.9.1	· Track link		150 x 2(330 x 2)	←
3.	Attachment (incl. 3.1~3.3)		1,040(2,290)	←
3.1	· Bucket assy [0.25 m^3 (0.33cu yd) STD]		210(460)	←
3.2	· Arm assy [1.73m (5ft-8in) STD.] (incl. following)		280(620)	←
3.2.1	· · Arm		150(330)	←
3.2.2	· · Bucket cylinder	※	64(140)	←
3.2.3	· · Idler link		18(39)	←
3.2.4	· · Bucket link		18(39)	←
3.2.5	· · Pin (2 pcs for mounting the arm cylinder and the bucket)		11(24)	←
3.3	· Boom assy (includes the following :)		540(1,190)	←
3.3.1	· · Boom		440(970)	←
3.3.2	· · Arm cylinder	※	93(200)	←
3.3.3	· · Pin (mounting the arm)		8(18)	←
4.	Oil, grease, water, etc. (incl. 4.1~4.3)		220(480)	←
4.1	· · Hydraulic oil, engine oil		104(230)	←
4.2	· · Fuel		107(240)	←
4.3	· · Water		10(22)	←

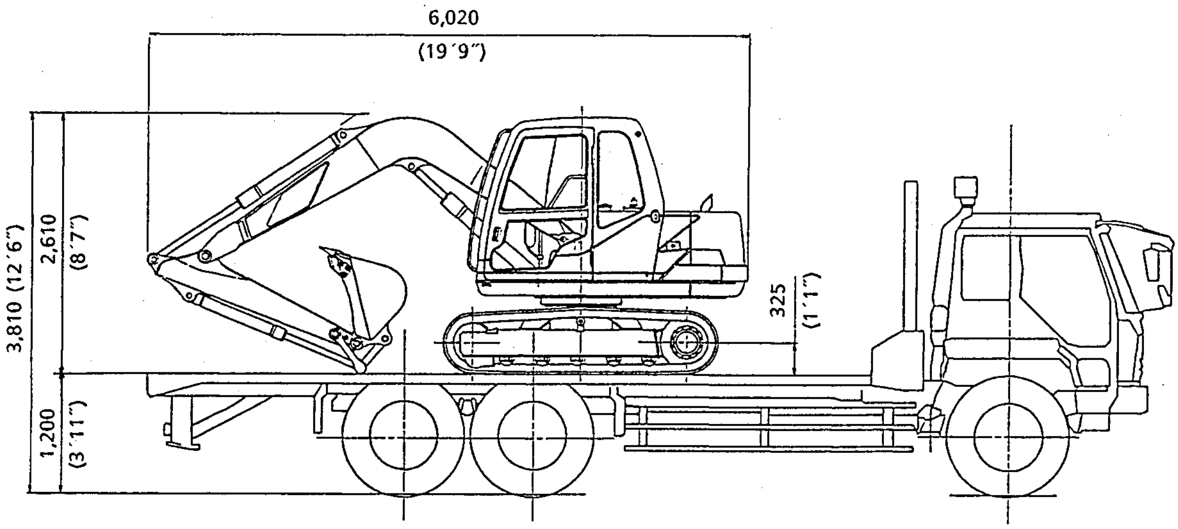
※ mark dry weight.

3. TRANSPORTATION WEIGHT

3.1 PRINCIPAL PARTICULARS OF A FULLY-EQUIPPED MACHINE ON A TRAILER

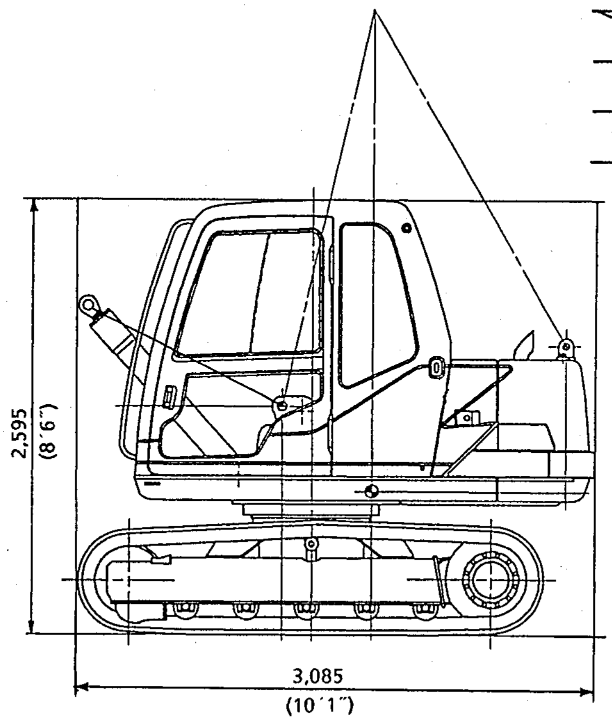
Unit : mm (ft-in)

	400mm (16") shoe	600mm (24") shoe
Total width (UPP)	2,180mm (7 ft-2 in)	2,300mm (7 ft-7 in)
Weight	6.4ton (14,100 lbs)	6.67ton (14,700 lbs)


6,020
(19'9")
3,810 (12'6")
2,610
(8'7")
325
(1'1")
1,200
(3'11")

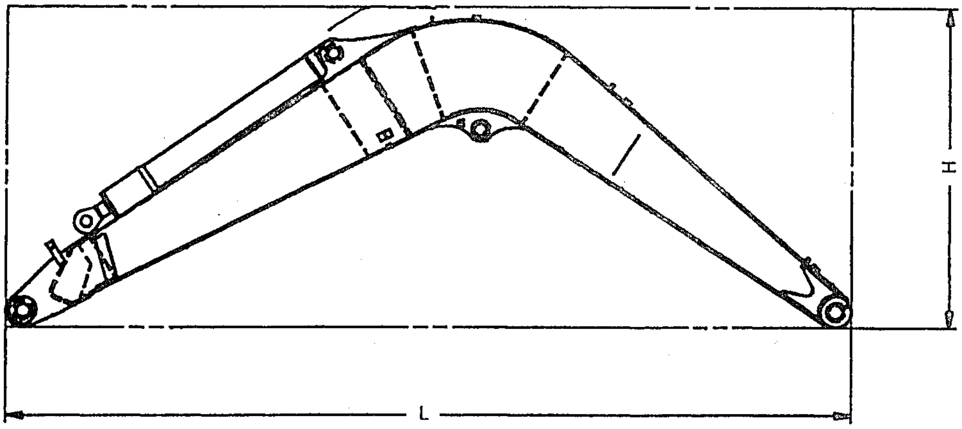
3.2 BASIC MACHINE LIFTING

	400mm (16") shoe	600mm (24") shoe
Width	2,180mm (7ft-2in)	2,300mm (7ft-7in)
Weight	5.4ton (11,800 lbs)	5.6ton (12,400 lbs)


2,595
(8'6")
3,085
(10'1")

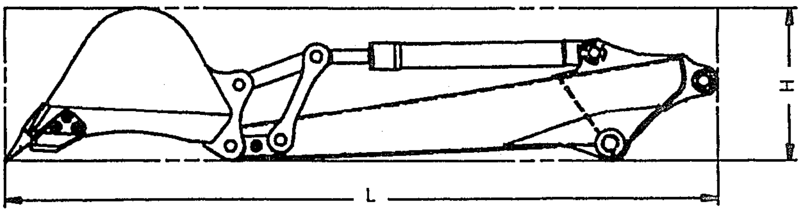
3.3 PRINCIPAL PARTICULARS OF BOOM

Range	3.7m (12ft-2 in)
Total length x total height x total width L x H x W m (ft-in)	3.85 x 1.45 x 0.40 (12′6″ x 4′9″ x 1′4″)
Weight kg (lbs)	530 (1,170)



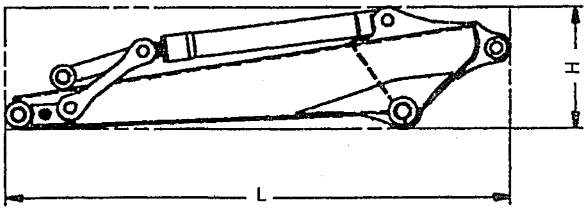
3.4 PRINCIPAL PARTICULARS OF ARM + BUCKET

Combination	1.73m(5ft-8 in) arm + 0.25m^3 (0.33cuyd) bucket	2.15m(7ft-1 in) arm + 0.2m^3 (0.26cuyd) bucket	1.73m (5ft-8 in) arm + 0.45m (1ft-6 in) extension arm + 0.2m^3 (0.26cuyd) bucket
Total length x total height x total width L x H x W m (ft-in)	3.26 x 0.70 x 0.77 (10′8″ x 2′4″ x 2′6″)	3.68 x 0.70 x 0.65 (12′1″ x 2′4″ x 2′2″)	3.71 x 0.70 x 0.65 (12′2″ x 2′4″ x 2′2″)
Weight kg (lbs)	490 (1,080)	490 (1,080)	590 (1,300)



3.5 PRINCIPAL PARTICULARS OF ARM

Length of arm	1.73m(5ft-8 in) arm	2.15m(7ft-1 in) arm	1.73m(5ft-8 in) + 0.45m (1ft-6 in) with extension arm
Total length x total height x total width L x H x W m (ft-in)	2.28 x 0.56 x 0.30 (7′6″ x 1′10″ x 1′)	2.70 x 0.56 x 0.30 (8′10″ x 1′10″ x 1′)	2.75 x 0.56 x 0.43 (9′ x 1′10″ x 1′5″)
Weight kg (lbs)	280 (620)	310 (680)	410 (900)

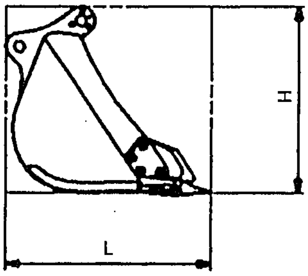


3.6 PRINCIPAL PARTICULARS OF BUCKET

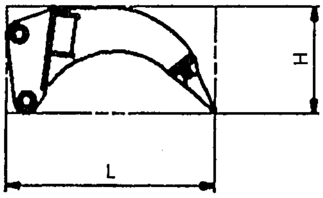
Type	Hoe bucket			
Total length × total height × total width L×H×W m (ft-in)	1.10×0.60×0.40 (3′7″×2′×1′4″)	0.98×0.89×0.56 (3′3″×2′11″×1′10″]	0.98×0.89×0.65 (3′3″×2′11″×2′2″]	0.98×0.89×0.77 (3′3″×2′11″×2′6″]
Weight kg (lbs)	160 (350)	170 (370)	180 (400)	210 (460)
Bucket capacity m^3 (cuyd)	0.1 (0.13)	0.16 (0.21)	0.2 (0.26)	0.25 (0.33)

Type	Hoe bucket	V-bucket	Slope finishing bucket	Ripper
Total length × total height × total width L×H×W m (ft-in)	0.98×0.89×0.82 (3′3″×2′11″×2′8″)	1.08×0.47×1.41 (3′6″×1′6″×4′7″)	0.79×0.62×1.50 [2′7″×2′×4′11″]	1.11×0.56×0.40 [3′8″×1′10″×1′4″]
Weight kg (lbs)	220 (490)	180 (400)	300 (660)	210 (460)
Bucket capacity m^3 (cuyd)	0.3 (0.39)	0.2 (0.26)	0.2 (0.26)	—

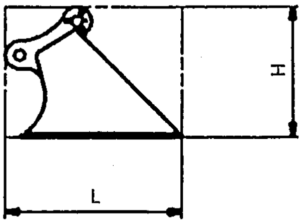
- Hoe bucket



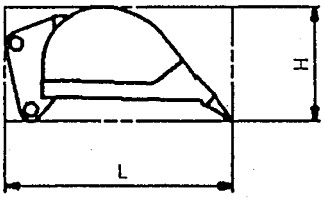
- Ripper



- Slope finishing bucket



- V-bucket



BooK code No. S5LE0406E

KOBELCO

SHOP MANUAL SK60

MAINTENANCE STANDARDS AND TEST PROCEDURES

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KOBE STEEL, LTD.

Applicable Machines
LE-11001~

Revision	Date of Issue	Remarks
First edition	August, 1990	S5LE0406E K

1. GENERAL

1) The terms used in this Maintenance Standards shall have definitions as follows:
   Standard value:
   Standard values for adjustment or assembly of a new machine, provided the values are for standard specifications (machine with standard attachments and shoes) unless otherwise specified.
   Allowable value:
   A limit value that shall not be exceeded. If it is exceeded, remedy or replacement is required. Avoid using a machine, exceeding this value to maintain the performance or safety of the machine.
   Limit value of use:
   A value at which machine adjustment or parts replacement becomes unnecessary if it is exceeded. If the machine is still used beyond the limit value, the machine will be faced with failures leading to the out-of operation and will develop safety problems.
   Oil temperature:
   Temperature to be applied. The temperature of hydraulic oil refers to that in the hydraulic oil tank. Hydraulic oil must be circulated continuously so that the oil temperature in the circuits may be leveled off with that of the tank.
2) For items without allowable values, adjust and repair or replace them with reference to the standard values.
3) Rubber products such as hydraulic hoses, O rings and oil seals deteriorate with time. Replace them regularly or at overhaul.
4) It is advisable that important hoses for safety purpose be designated as very important parts (V.I.P.) and be replaced regularly.
5) In proceeding to maintenance, it is essential to get familiar with machine operating procedures, precautions to be observed and inspection / lubrication procedures. Read through the Operators Manual as well.

2. PRESSURE MEASUREMENT AND ADJUSTMENT

2.1 EQUIPMENT TO BE PREPARED

Pressure gauge	70kgf/cm^2 (1000 psi)	3 pcs
	500kgf/cm^2 (7000 psi)	2 pcs
Pressure measuring set		1 set
Surface thermometer (with magnet)		1 pcs
Hydraulic oil analyzing apparatus		1 set

2.2 STANDARD MEASURING CONDITION

Within standard measuring condition in Performance Inspection Standard Table (Table 1)

(1) Measuring Procedure and Method

1) Measuring the cleanliness of operating oil
   Measure cleanliness with an analysis apparatus after taking sample oil from the operating oil tank. If the oil shows a cleanliness exceeding an allowable value, flush the oil or replace the filter.
2) Raising the temperature of the operating oil
   Attach a thermometer in the surface of the operating oil tank and measure temperature. Wait till the temperature rises by raising the boom or by relieving the bucket relief valve.
3) Raising the water temperature
   Attach a thermometer in the surface of the radiator and measure the temperature. Run the engine and wait till temperature rises.

2.3 READING THE ENGINE REVOLUTION

Following is a procedure whereby the engine revolution is read on the multi-display:

1) With the buzzer stop switch turned to "ON", turn the starter key switch to "ON". However, keep the engine stopped. (See Fig. 2.)
2) Depress the buzzer stop switch five times and get an engine rotation mark and a controller part number.
3) Depress the buzzer stop switch by turns. An engine revolution will be indicated at the 23rd out of 24 pressings. (Fig. 3.)
4) If the engine is started here, the display will be as shown on the right, for instance. (Fig. 4.)
5) Turn off the auto acceleration select switch
6) Set the throttle lever to the maximum revolution "HI".
7) Change over the operation mode (KPSS) switch to H,FC by turns and compare the revolution at no load with an existing revolution.
8) If the revolution falls within a tolerance, determine that the engine and the controller are normal, and measure and adjust the pressure of the hydraulic circuit.
   Revolution at no load = present revolution $^{+50}_{-50}$
9) If the revolution runs out of a tolerance, adjust the revolution according to the procedure for the adjustment of the following mechatro controller.

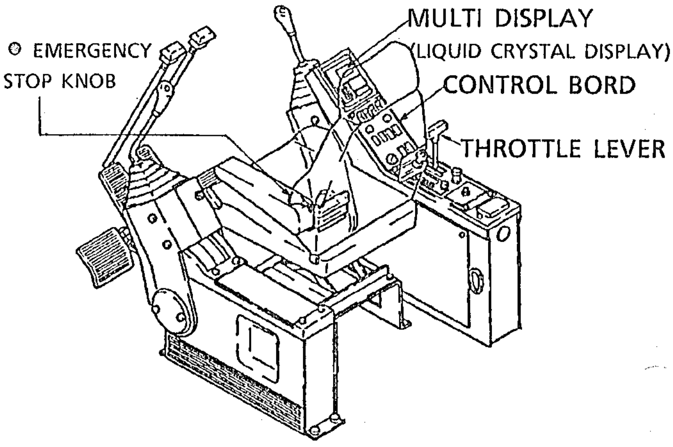


Fig. 1 Operating controls

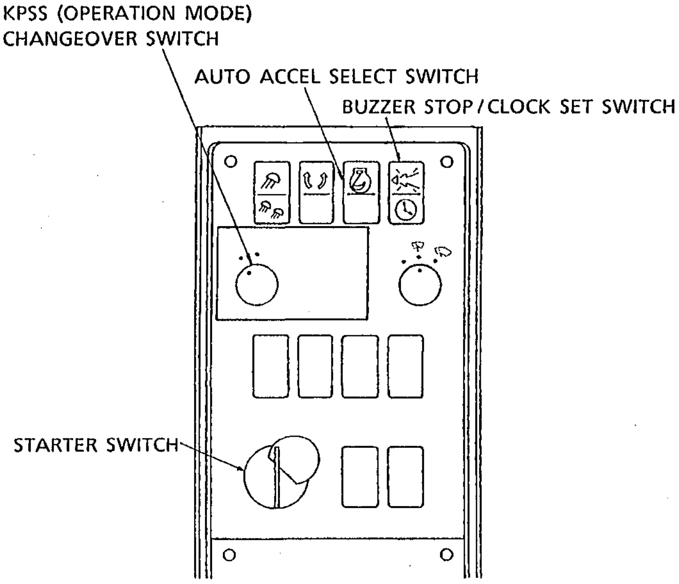

KPSS (OPERATION MODE) CHANGEOVER SWITCH
AUTO ACCEL SELECT SWITCH
BUZZER STOP/CLOCK SET SWITCH
STARTER SWITCH

Fig. 2 Control bord

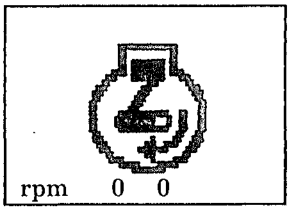
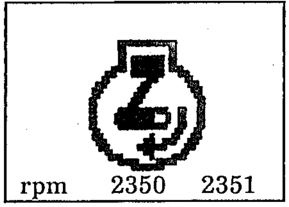


Fig. 3 Displaying the engine revolution when the engine is at rest



- 2351 ······· Present revolution
- 2350 ······· No-load revolution at mechatro adjustment (Hereinafter called no-load revolution)
- rpm ------- Revolution

Fig. 4 An example of engine revolution display when running

2.4 ADJUSTING THE ENGINE REVOLUTION BY MECHATRO CONTROLLER

The adjustment of the mechatro controller which will be mentioned hereinunder must be performed whenever the above engine revolution runs out of a target tolerance or whenever either the controller or the stepping motor is replaced. If you follow the adjusting procedure incorrectly, adjustment data may be broken. Always stick to the procedure and reminders.

〔 Procedure for adjusting the engine revolution 〕

(1) Setting engine stop high positions
1) Read and reset an adjust signal (TEST).
2) Adjustment start condition
3) Adjustment signal timing
4) Setting the engine revolution stop position
5) Setting engine revolution high speed position
6) Fixing engine revolution high speed position
7) Storing engine revolution high speed position

(2) Setting engine revolution
1) Read and reset an adjust signal (TEST).
2) Adjustment start condition
3) Adjustment signal timing
4) Storing the revolution and position of the stepping motor
5) Closing the reading of adjust signals (RUN)

2.5 SETTING THE ENGINE STOP AND HIGH POSITIONS

(1) Prepare to read and reset (TEST) an adjust signal.

1) Take off the operator seat and remove seat suspension (1) fixed to the seat stand.

2) Remove cap (2) of the controller.

3) After confirming that the engine key is at "OFF".
Push the adjust switch (3) in the controller in the TEST direction through the hole in the rubber cap, read and reset an adjust signal.

⚠ Adjustment data may be broken unless the switch (3) is pressed with the engine key in "OFF" position.

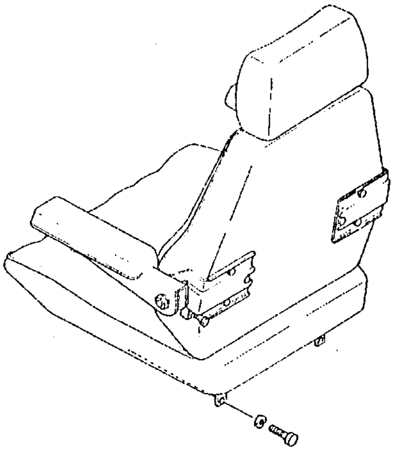


Fig. 5 Removing the operator seat

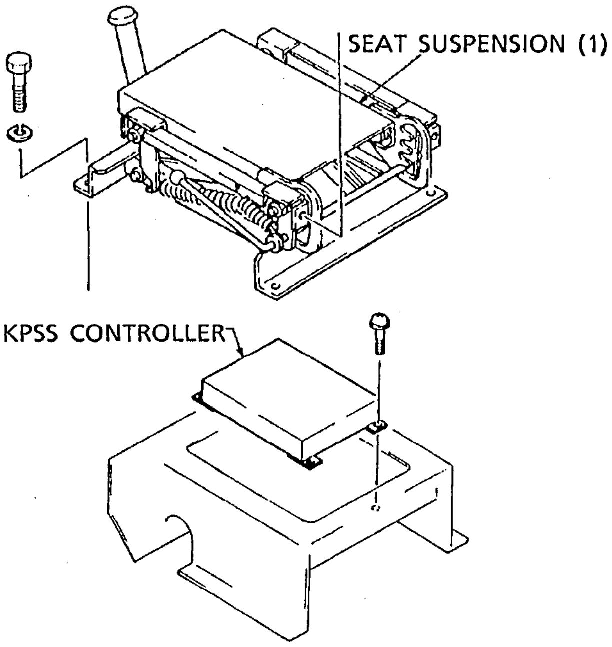


Fig. 6 Mounted position of mechatro controller

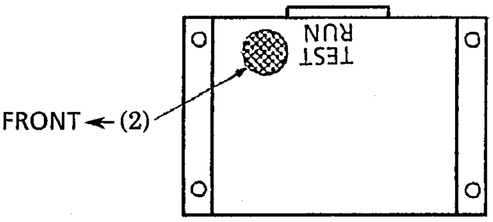


Fig. 7 Removing controller cap (2)

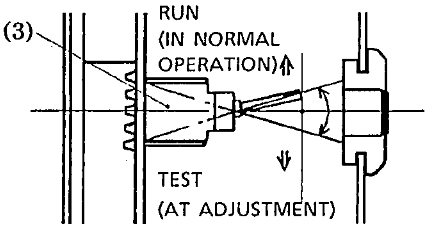


Fig. 8 Direction of pushing the adjust switch in the controller

(2) Adjustment start condition

1) Adjust switch in controller·········TEST

2) KPSS (operation mode)
changeover switch ·······H mode

3) Auto accel select switch··············ON

4) Throttle lever ·····························Low idle

5) Starter key ····Engine at rest with the starter switch "ON"

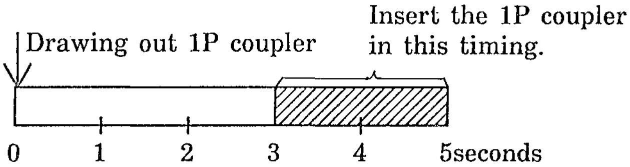
(3) Adjust signal timing

1) Adjust signal

To receive an adjust signal that actuates the stepping motor, pull out and put in 1P coupler (4) at the inlet of the controller.

2) Adjust timing

There is a timing at which IN /OUT signals of the 1p coupler work effectively. The timing is limited to two seconds in the hatching of the below figure.



☞ If it is set within an adjust timing, "CPU" is indicated on the magnetic display, implying that it has entered adjustment. Then the stepping motor runs itself to the stop position.

3) When insertion of the 1P coupler runs out of the adjustment timing:

When a time display appears on the multi display even if the 1P coupler is inserted, draw out the 1P coupler above match the insertion timing.

(4) Adjust signal reset operation

1) Pull out the 1P coupler for initial adjustment and put it in again within a few seconds.

2) Lighting the CPU display and transferring the motor stop position

A CPU indication appears on the multi display and the stepping motor runs to the engine stop position.

(5) Procedure for setting an engine stop position

1) Turn the stepping motor lever (8) clockwise to 22.5^{0}-360°/23 from the perpendicular line.

2) Connect the control cable to the fixing bracket and the lever (8) and arrange them as shown in the figure 13.

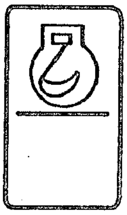


Fig. 9 Auto accel select switch

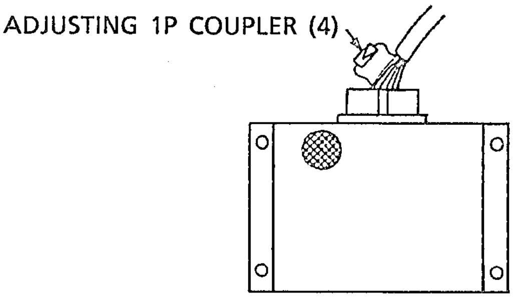


Fig. 10 Position of the adjusting 1P coupler of the controller

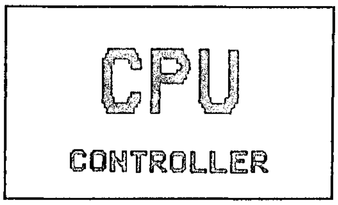


Fig. 11 CPU indication on multi display

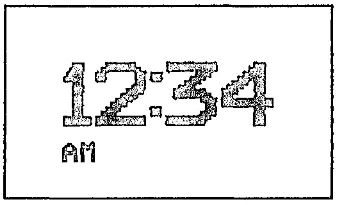


Fig. 12 An example of time display on the multi display

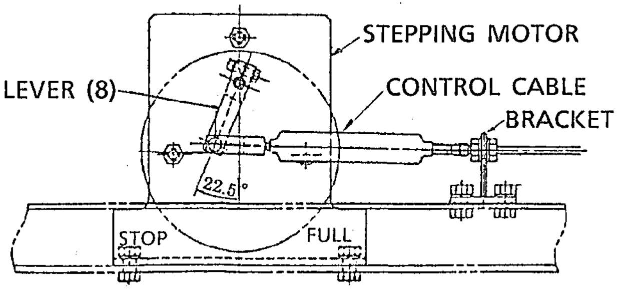


Fig. 13 Stop position of stepping motor

3) On the engine side also, attach the control cable to the mounting bracket. Then put a 0.2mm (0.008in) thickness gauge between the engine governor lever (7) and the stop adjust bolt and press it till it hits the bottom.
In that position, lock the control cable nut to the engine side bracket.

4) Re-confirm the 0.2mm (0.008in) clearance.

(6) Procedure for adjusting the high speed position on the engine side

1) Pull out the 1P coupler for second adjustment. Then, the power to the stepping motor is shut off.

2) The lever (8) of the stepping motor is freed and can be moved by hand. Then turn the lever counterclockwise (to FULL) to the full by hand.

3) Put a 0.2mm (0.008in) thickness gauge between the engine governor lever (7) and the stop adjust bolt on the high speed side (on your left), push it till it hits the bottom and hold it in that condition.

4) Insert the 1P coupler for second adjustment. Then the stepping motor is powered and locked at high position.

5) Make sure once again of the 0.2mm (0.008in) clearance.

6) Pull out the 1P coupler for 3rd adjustment and then put it in. Then the stepping motor runs itself and moves toward the stop side. This completes all adjustments, and the CPU display goes out.

7) Where you wish to perform fine adjustment of the 0.2mm (0.008in) clearance under 5).

If the controller is 2480U310F2 and 2480U310F5, the stepping motor rotates about 0.04mm (0.0016in) in the high idle direction if the auto acceleration select switch is "ON" and in the low idle direction if the auto acceleration select switch is "OFF", each time the buzzer stop switch is turn "ON". Adjust the clearance using this function.

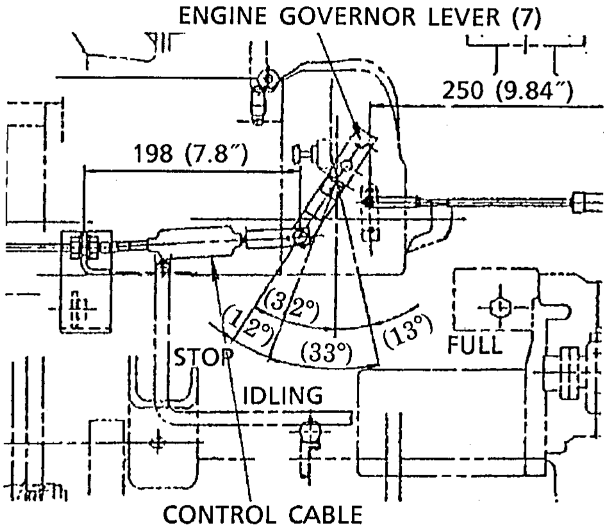


Fig. 14 Mounting position of control cable

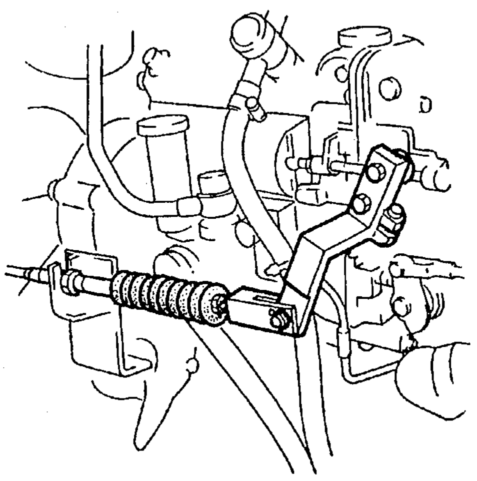


Fig. 15 Setting the high speed position by clearance adjustment

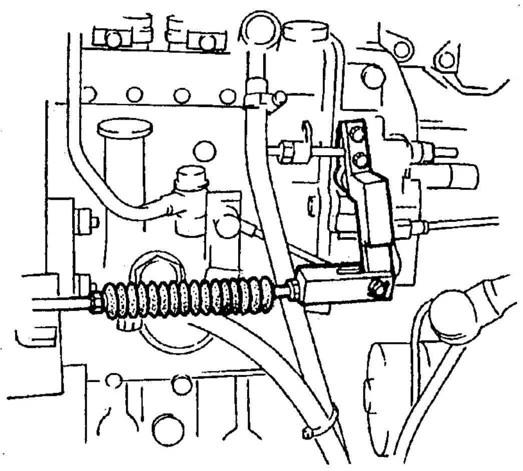


Fig. 16 Setting the high speed position by clearance adjustment

2.6 SETTING THE ENGINE REVOLUTION

(1) Read and reset an adjust signal (TEST).
Perform it the same way with the adjust switch (3) in the controller at TEST.

(2) Adjust reset condition.

1) Adjust switch in controller················· TEST
2) KPSS (operation mode) select switch·· H mode
3) Auto accel select switch······················ $\boxed{\text{OFF}}$
4) Throttle lever································ LOW IDLE
5) Engine ·· $\boxed{\text{RUNNING}}$

Differences in setting the engine stop and high positions in para. 2.5 are those surrounded by a rectangle.

(3) Adjust signal timing

1) Draw out 1P coupler (4) and then insert 3~5 seconds later the same way as above.
2) Confirming that the CPU display is lit.
The same as above.

(4) Storing the rotating position of the stepping motor
The stepping motor runs itself from a position further below LOW IDLE (a little above ENGINE STOP) to HI IDLE to read and store engine revolutions.

☞ ◉ If the controller is 2480U310F1 or 2480U310F2, the adjustment under (7) must be additionally required.
◉ If the engine key is turned "OFF" during adjustment, storage gets unstable.
In that case, adjust it once again.

(5) Confirming that the CPU display is off
Confirm that CPU display is off on the multi display.

(6) Blocking reading adjust signals (RUN)
More than four seconds after the engine key is turned to OFF, turn the adjust switch (3) in the controller to "RUN".

Four seconds after the engine key is turned "OFF", power supply is turned off. Adjustment data may be broken in some cases if adjust switch (3) is depressed when power supply is on.

(7) If the controller is 2480U310F1 or 2480U310F2 is under item (4), pull out the 1P coupler and put it in once again.Otherwise, self running, reading and storge do not begin.

This manipulation is not neccssary on 2480U310F5.

2.7 PRESSURE MEASURING POSITIONS

(1) Ports (a1, a2) for tapping the main circuit pressure

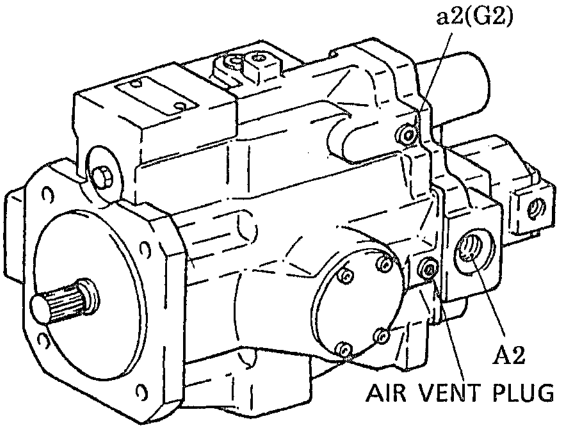


Fig. 17 a2 side / EY circuit pressure tapping port

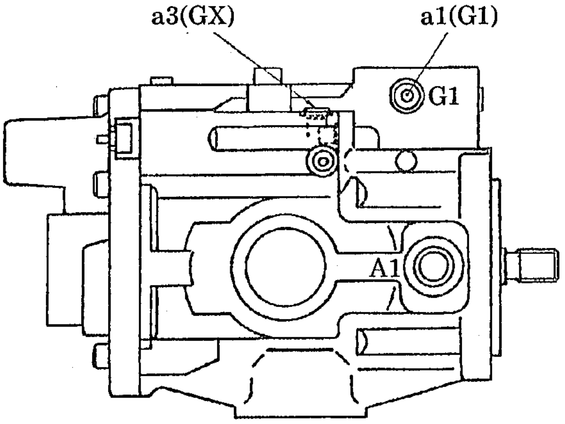


Fig. 18 a2 side / EY circuit pressure tapping port

2.8 MEASURING AND ADJUSTING THE CIRCUIT PRESSURE

(1) Procedure for measurement

1) Do not adjust pressure if measured values fall within the tolerances of Table 1. In case adjustment is necessary, the target shall be:

$$\text{Standard value} + \frac{\text{Tolerance (upper limit + lower limit)}}{2}$$

2) Measure port pressures by tightening the main relief valve after measuring the main relief pressure. (Marking on the adjusted points will promote restoration of pressure.)

(2) Procedure for Measurement

As mentioned above, attach a pressure gauge, adjust the water and oil temperature conditions within standard ranges, confirm the engine revolution and measure pressure according to the following procedure:

1) Measure the primary pilot pressure.
2) Measure the main relief pressure and tighten the adjust screw up.
3) Measure the port relief pressure.
4) Measure the swing port relief pressure.
5) Measure the travel relief valve pressure.
6) Bring the adjusted main relief valve pressure back to its original level.

(3) Pressure adjustment

1) Measuring the primary pilot pressure

Location ········· Port a3 that taps the pilot circuit pressure in Fig. 19

Method ··········· When all operating levers are neutral

Adjustment ····· By means of the adjust screw (RV13) of the pilot relief valve

2) Measuring and tightening the main relief pressure

Location ········· Ports a1 and a2 that tap the main circuit pressure

Method ··········· Bucket digging (a1 side)
Boom hoisting (a2 side)

Adjustment ···· Main relief MR1 and MR2
Tighten the adjust screws 180 deg. to measure the pressure of ports. (because it is lower than the port pressure.)

3) Measuring the port relief pressure

Location ········· Port a1 or a2 that taps the main circuit pressure

Method ··········· Refer to "Measurement" in Table 1.

Adjustment ···· Port relief valves (RV9-RV12)

4) Measuring the swing port relief pressure

Location ········· Ports PA and PB (See Fig. 21.) of the swing control valve

Method ··········· Lock the bucket with the shoe plate.

Adjustment ···· Swing relief valves RV11 and RV12

5) Measuring the travel main relief pressure

Location ········· Ports a1 and a2 that tap the main circuit pressure

Method ··········· Operate both the RH and LH sides (front and back) at the same time at 2-speed and in the H mode. (Lock both sprockets.)

Adjustment ···· Travel relief valves (TR1 and TR2)

6) Returning the adjusted main relief valve pressure

Lastly, return the adjust screw of the main relief valve 180 deg. or to the matching mark point so it falls within a standard tolerance.

7) Pilot circuit pressure tapping port

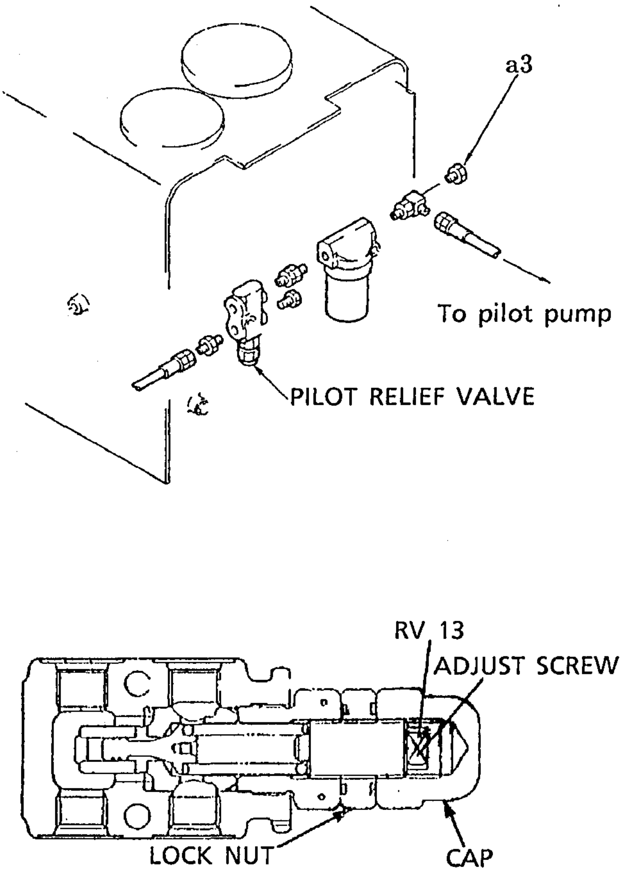
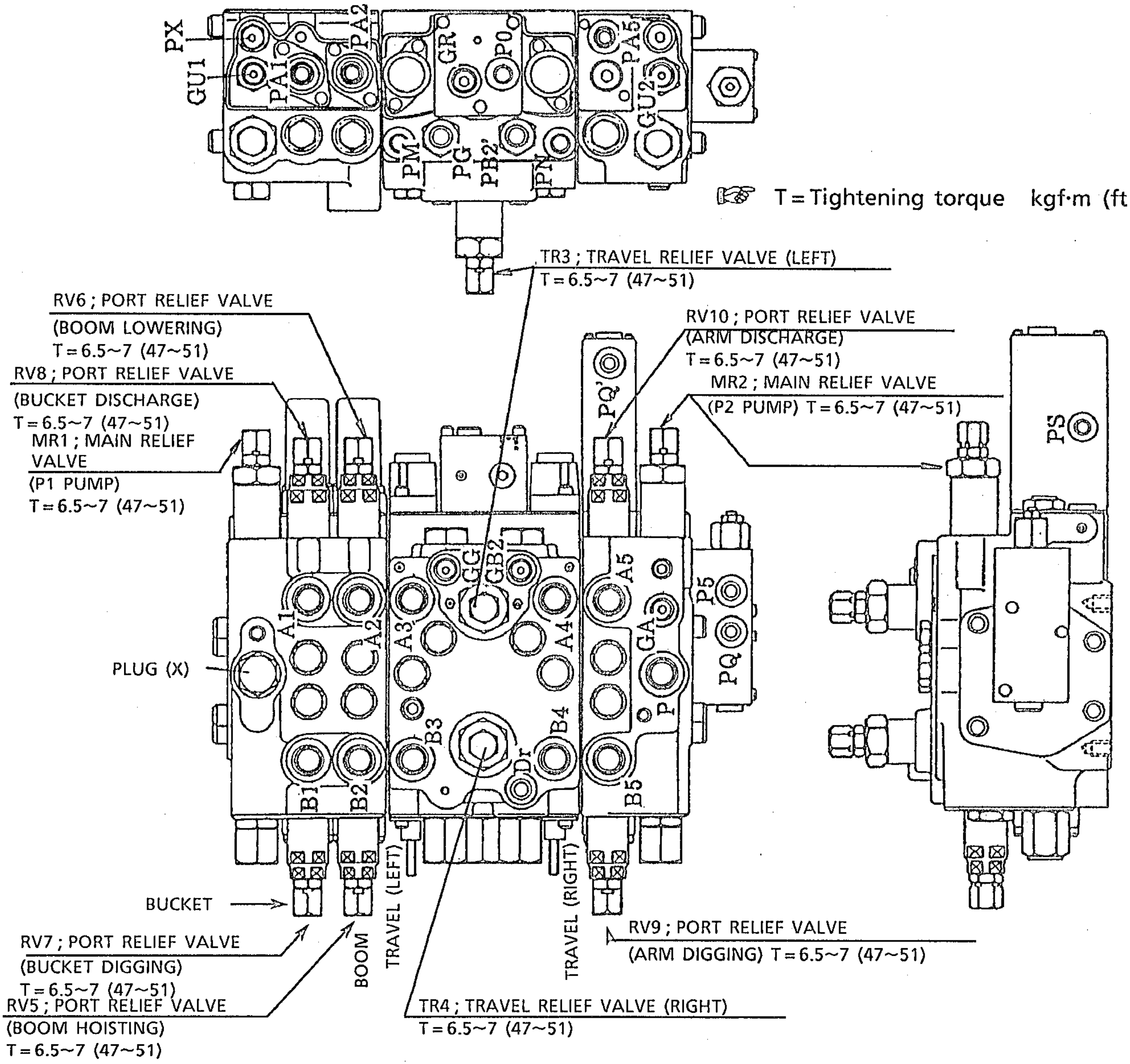


Fig. 19 Pilot circuit pressure tapping port a3 and relief valve adjust screw


PX
GU1
PA1
PA2
GR
P0
PA5
GU2
PM
PG
PB2'
PN
PQ'
PS
GG
GB2
A1
A2
A3
A4
A5
P5
GA
PQ
P
B1
B2
B3
B4
B5
Dr
PLUG (X)
BUCKET
BOOM
TRAVEL (LEFT)
TRAVEL (RIGHT)

☞ T = Tightening torque kgf·m (ft·lbs)

TR3 ; TRAVEL RELIEF VALVE (LEFT)
T = 6.5~7 (47~51)

RV6 ; PORT RELIEF VALVE
(BOOM LOWERING)
T = 6.5~7 (47~51)

RV8 ; PORT RELIEF VALVE
(BUCKET DISCHARGE)
T = 6.5~7 (47~51)

MR1 ; MAIN RELIEF VALVE
(P1 PUMP)
T = 6.5~7 (47~51)

RV10 ; PORT RELIEF VALVE
(ARM DISCHARGE)
T = 6.5~7 (47~51)

MR2 ; MAIN RELIEF VALVE
(P2 PUMP) T = 6.5~7 (47~51)

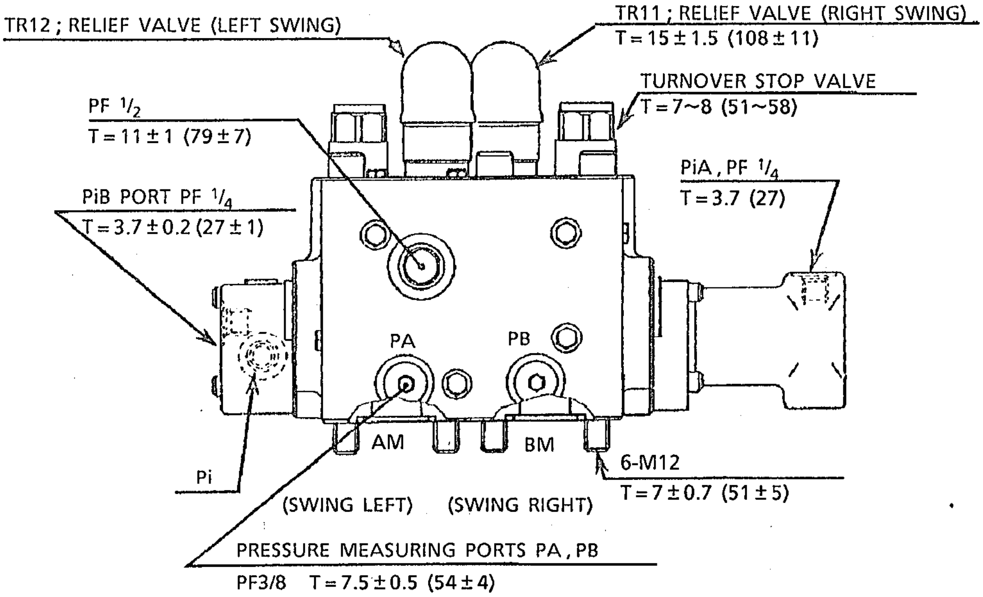
RV7 ; PORT RELIEF VALVE
(BUCKET DIGGING)
T = 6.5~7 (47~51)

RV5 ; PORT RELIEF VALVE
(BOOM HOISTING)
T = 6.5~7 (47~51)

RV9 ; PORT RELIEF VALVE
(ARM DIGGING) T = 6.5~7 (47~51)

TR4 ; TRAVEL RELIEF VALVE (RIGHT)
T = 6.5~7 (47~51)

Fig. 20 Main control valve


PA
PB
AM
BM
(SWING LEFT)
(SWING RIGHT)
Pi

TR12 ; RELIEF VALVE (LEFT SWING)

TR11 ; RELIEF VALVE (RIGHT SWING)
T = 15 ± 1.5 (108 ± 11)

TURNOVER STOP VALVE
T = 7~8 (51~58)

PF 1/2
T = 11 ± 1 (79 ± 7)

PiB PORT PF 1/4
T = 3.7 ± 0.2 (27 ± 1)

PiA , PF 1/4
T = 3.7 (27)

6-M12
T = 7 ± 0.7 (51 ± 5)

PRESSURE MEASURING PORTS PA , PB
PF3/8 T = 7.5 ± 0.5 (54 ± 4)

Fig. 21 Outside view of swing control valve (As seen from blow)

2.9 PERFORMANCE INSPECTION STANDARD

Table 1

(NOTE ; Take measurement in the S mode, unless otherwise specified.
The standard tolerance shall be an allowable range in field measurements.)

Inspection item				Pressure measurement			Bench test value	※ Tolerance		Unit	Control	Measurement
				Position	Port	Size						Condition, function
Standard measuring condition	Cleanliness of hydraulic oil			Hydraulic oil in tank			8	+1	−1	Class	−	Takeout of sample
	Temperature of hydraulic oil			Tank surface			50 (122)	+5 (+9)	−5 (−9)	°C (°F)	−	Air temperature 50°∼−10°C (122∼14)
	Water temperature			Radiator surface			75 (167)	+15 (+27)	−15 (−27)		−	Air temperature 50°∼−10°C (122∼14)
	Engine revolution	Low idle		Multi display			875	+25	−25	rpm	Adjustment not neccessary	FULL throttle
		Hi idle					2350	+50	−50			
		S										
		FC					1900	+50	−50			
		Decel					1050	+50	−50			
Main circuit	Main relief pressure	Attach	RH	Pump	a1	PF1/4	210 (2990)	+5 (+71)	0 (0)	kgf/cm^2 (psi)	MR1	Bucket digging
			LH		a2						MR2	Boom hoisting
		−					−	−	−		−	
											−	
		Travel	RH		a1		260 (3700)	+5 (+71)	0 (0)		TR1	Simultaneous RH/LF operation in H mode and at 2-speed
			LH		a2						TR2	
	Port relief pressure	Boom	R	Pump	a1		240 (3410)				RV6	Mode H Main relief pressure range 190∼215K (2700∼3060)
			H				240 (3410)				RV5	
		Arm	R		a2		240 (3410)				RV10	Mode H Main relief pressure range 210∼215K (2990∼3060)
			H								RV9	
		Bucket	R		a1		240 (3410)				RV8	
			H				240 (3410)				RV7	
		Swing	RH		a2		175 (2490)	+40 (+569)	0 (0)		RV11	
			LH								RV12	
Pilot circuit	Primary pressure	Discharge pressure		G pump	P	PF1/4	35 (498)	+2 (+28)	−1 (−14)		−	Mode H
	KPSS Soleniod proportional valve for secondary pressure	H		Pump	a3	PF1/4	0 (0)	+1 (+14)	0 (0)		−	
											−	
		FC					7 (100)	+2 (+28)	−1 (−14)		−	
											−	
		Release									−	
		Boost pressure										

※ Tolerance ;
The upper and lower limits, when added or subtracted to the bench test value, provide an acceptable range when measuring pressures on a actual machine.

2.10 PROCEDURE FOR ADJUSTING THE PRESSURE OF INDEPENDENT RELIEF VALVES

1) Procedure for Adjusting the Main Relief Valve
Turning the adjust screw clockwise increases the pressure, while turning it counterclockwise decreases the pressure. References for pressure variations are as follows:

Table 3

Turn of adjust screw	Pressure change kgf/cm2 (psi)
1/2 turn	about 54 (768)
1/4 turn	about 27 (384)

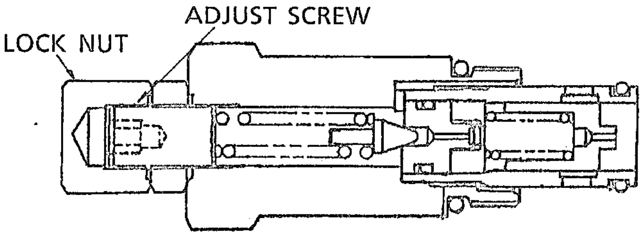


Fig. 22 Main relief valve (71B)

2) Adjustment procedures for travel relief valve and port relief valve
Turning the adjust it counterclockwise decreases the pressure. Given below are the pressure changes for reference:

Table 4

Turn of adjust screw	Pressure change kgf/cm2 (psi)
1/2 turn	about 62 (882)
1/4 turn	about 31 (441)

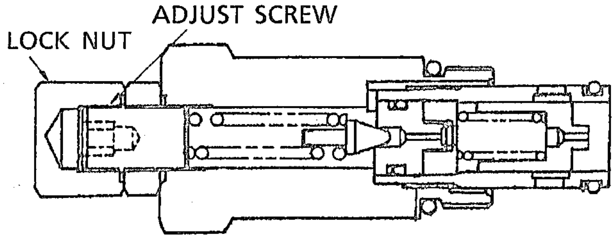


Fig. 23 Travel relief valve (71A)

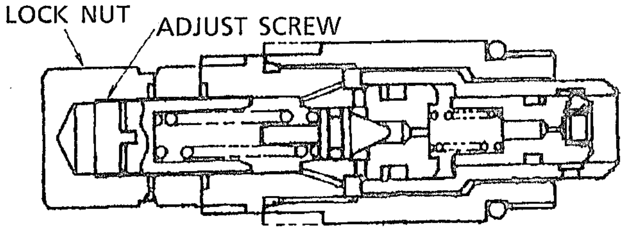


Fig. 24 Port relief valve (72)

3) Procedure for adjusting swing relief valve
Turning the adjust screw clockwise increases the pressure and turning the adjust screw counterclockwise decreases the pressure. Given below are guidelines of pressure variation.

Table 5

Turn of adjust screw	Pressure change kgf/cm2 (psi)
1 turn	about 52 (739)
1/4 turn	about 26 (370)

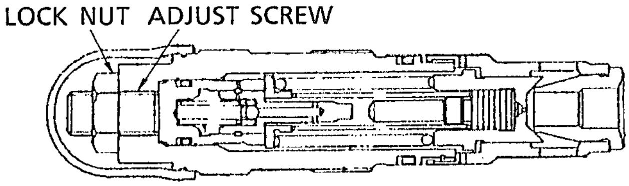


Fig. 25 Swing relief valve

4) Method of adjusting pilot relief valve
Turning the adjust screw clockwise increases the pressure and turning it counterclockwise decreases the pressure. Referential pressure changes are given below:

Table 6

Adjust screw rotation	Pressure change kgf/cm2 (psi)
1 Turn	about 14.4 (205)
1/4 Turn	about 3.6 (51.2)

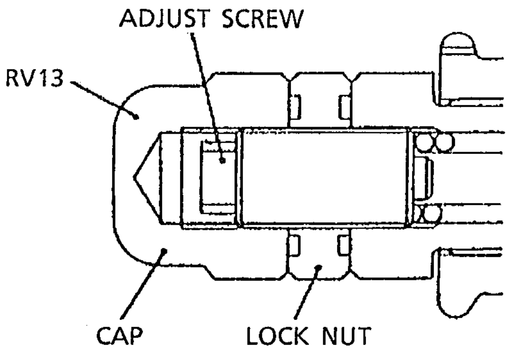

ADJUST SCREW
RV13
CAP
LOCK NUT

Fig. 26 Pilot pressure relief adjusting section

2.11 MEASURING THE SECONDARY PRESSURE OF THE SOLENOID PROPORTIONAL VALVE

(1) Pressure measuring position
Remove the plug of the gauge port GX (See Fig. 27.) of the main pump and attach a pressure gauge tapping joint and a 70kgf/cm^2 (1000psi) pressure gauge.

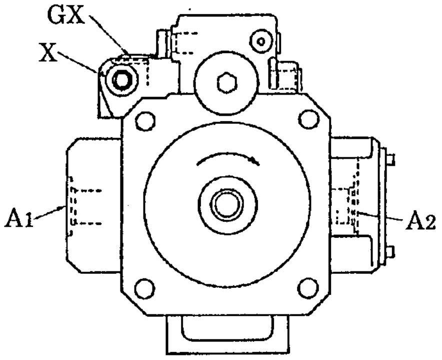
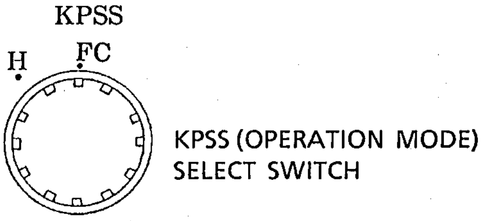


Fig. 27 Position of the secondary pressure tapping port GX on the solenoid proportional valve

(2) Measuring method and procedure

1) Measurement in H, FC modes
Change the operation mode switch to the H, FC modes by turns and measure the pressure.


KPSS
H
FC
KPSS (OPERATION MODE) SELECT SWITCH

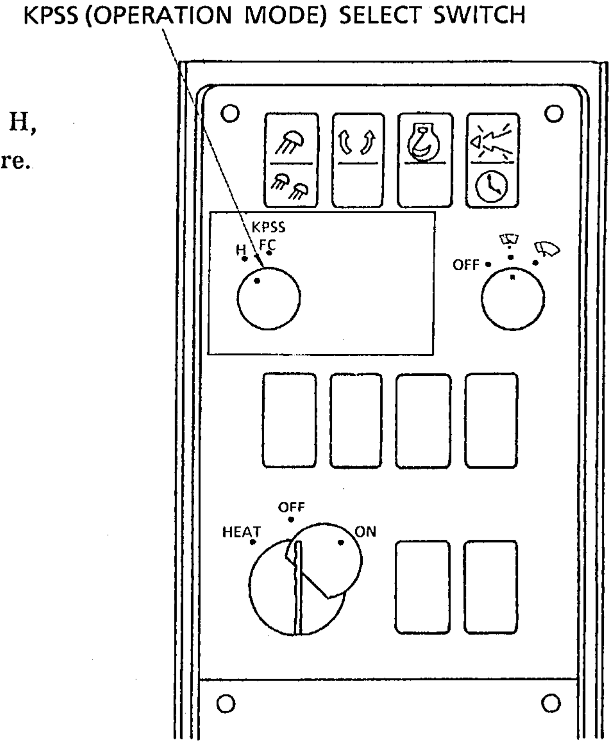
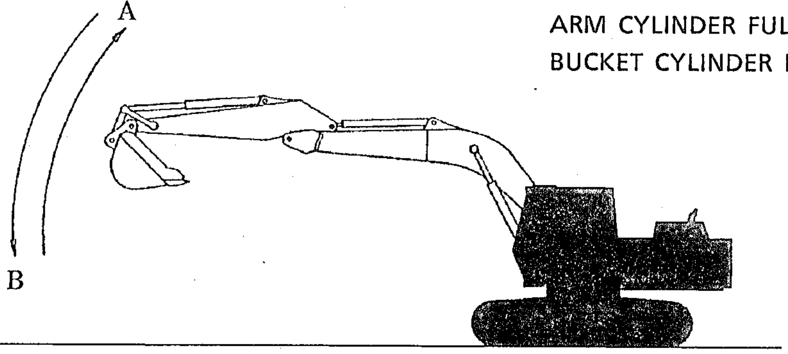

KPSS (OPERATION MODE) SELECT SWITCH
KPSS
H
FC
OFF
HEAT
OFF
ON

Fig. 28 KPSS select switch position

3. CYLINDER SPEED

Condition : Engine at high idling, oil temperature of 50±5°C (122±9°F).

Procedure : Measure the time from the most retracted (extended) condition to the most extended (retracted) condition of cylinders at lever full stroke with a stop watch, except that for the boom cylinder the time shall be from the ground level to the highest position. Make three measurements and record the average value.



CONDITION A, B :
ARM CYLINDER FULLY RETRACTED.
BUCKET CYLINDER FULLY EXTENDED.

Fig. 29

CONDITION C, D :
BOOM CYLINDER FULLY EXTENDED.
BUCKET CYLINDER FULLY RETRACTED.
CONDITION E, F :
SET THE ARM TIP POINT TO THE BOOM FOOT HEIGHT, AND SET THE ARM ABOUT 90° TO ARM CYLINDER.

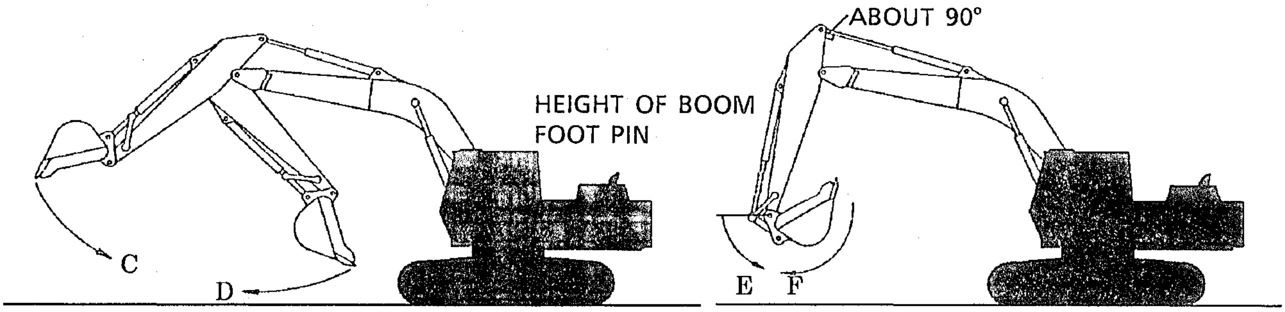


Fig. 30

Table 7 Unit : sec.

Symbol	Item	Standard value 1.73m (5′8″) ARM	
		MODE H	MODE FC
A	Boom cylinder extension	2.8~3.4	3.4~4.0
B	Boom cylinder retraction	2.9~3.5	–
C	Arm cylinder extension	3.5~4.1	3.8~4.4
D	Arm cylinder retraction	2.8~3.4	–
E	Bucket cylinder extension	3.6~4.2	–
F	Bucket cylinder retraction	2.5~3.1	–

☞ The operating time does not include the cushion stroke times.

4. CYLINDER OIL-TIGHTNESS

Condition :
Engine stopped, oil temperature of 50±5°C (122±9°F), fully retract the arm cylinder and hold the bucket (empty) at 1.5m (4ft-11in) above ground.
Procedure :
After keeping the machine for three minutes under the above condition, measure the movement of the cylinders and the fall of the bucket top end in ten minutes.

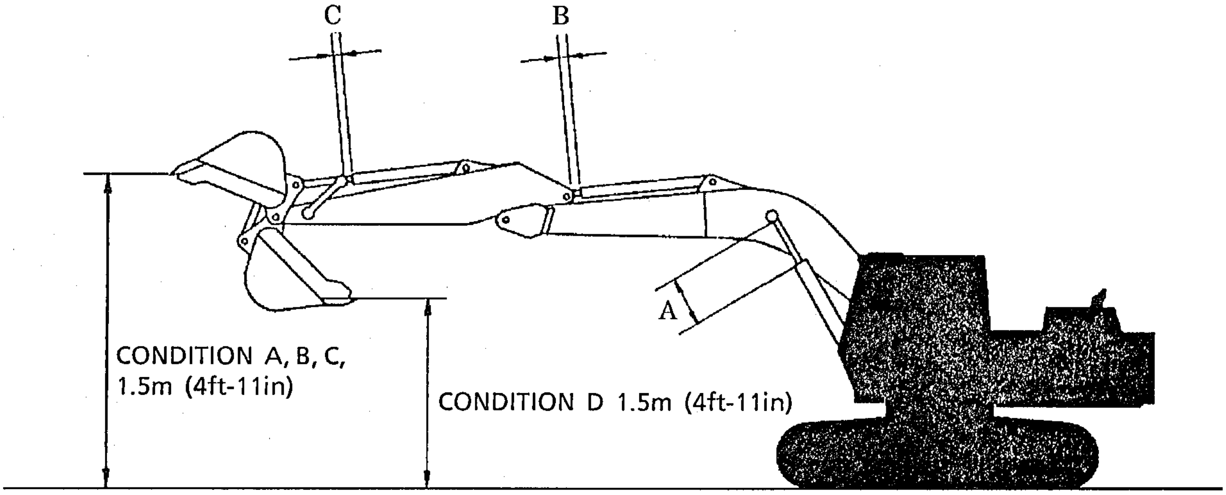

C
B
A
CONDITION A, B, C, 1.5m (4ft-11in)
CONDITION D 1.5m (4ft-11in)

Fig.31

Table 8 Unit : mm (in)

Symbol	Item	Standard value	Remarks
A	Boom cylinder (Retraction of rod)	Max. 25 (1.0″)	
B	Arm cylinder (Extension of rod)	〔 Max. 20 (0.8″) 〕	
C	Bucket cylinder (Extension of rod)	〔 Max. 10 (0.4″) 〕	
D	Fall of bucket top end	230mm (9.1in) / 10min	

〔 〕 The figures in parentheses are for reference.

5. SWING PERFORMANCE

A. Swing performance

Condition :

Engine at high idling, oil temperature of 50±5°C (122±9°F), fully retract the bucket cylinder and arm cylinder, and hold the bucket (empty) at 1.5m (4ft-11in) above ground.

Procedure :

Measure the time required to make two turns after one turn of start-up with a stop watch and give the time required to make one turn. Repeat it three times and give an average value.

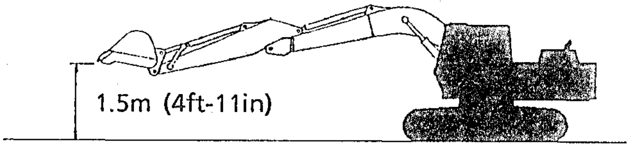


Fig. 32

B. Swing brake

Condition :

Engine at high idling, oil temperature of 50±5°C (122±9°F), fully extend the bucket cylinder and fully retract the arm cylinder, and hold the bucket (empty) at 1.5m (4ft-11in) above ground.

Procedure :

Measure the braking distance at the top end of the bucket, actuating swing relief valve after one turn of start-up. Repeat it three times on clockwise and counterclockwise direction respectively and give an average value for each direction.

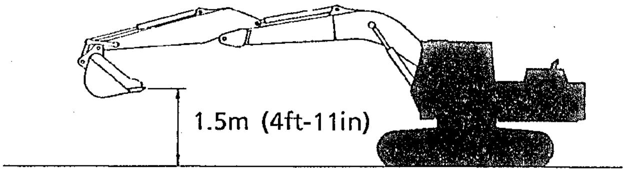


Fig. 33

C. Swing maintain performance

Condition :

Engine stopped, oil temperature of 50±5°C (122±9°F), fully retract the bucket cylinder and the arm cylinder, and set the machine on a 10 deg. Slope, holding the bucket at 1.5m (4ft-11in) above ground.

Procedure :

Direst the attachment perpendicular to the slope and measure the swing (overrun) at the bucket top end for 20 seconds. Measure it in both the clockwise and counterclockwise directions.

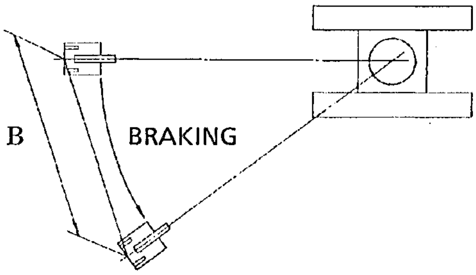


Fig. 34

Table 9

Symbol	Item	Standard value	Remarks
A	Swing speed	4.6~5.0sec/rev	
B	Swing brake performance	30°~60°	
C	Swing maintain performance	0mm/20sec (0 in/20 sec)	

☞ Measure the swing drift value in "C" 10 seconds after the engine stops.

6. TRAVEL PERFORMANCE

A. Travel deflection

Condition:

Engine at high idling, oil temperature of 50±5°C (122±9°F), on level solid soil, approach run more than 2m (6ft-7in).

Procedure:

Draw a target line parallel to the crawler and measure deflection in 20m (65ft-7in) of running. Repeat it three times and give an average value.

B. Travel speed

Condition:

Engine HI IDLE, oil temp. 50±5°C (122±9°F).

Procedure:

Measure the revolution of the sprocket for one minute, using a stop watch. Repeat it three times and take a mean value.

Table 10 Unit: rpm

Symbol	Item					Standard value
A	Travel deflection					0~1200mm
B	Revolution of sprocket rpm	Right	Advance	H	1	30.2~37.2
					2	45.1~55.3
			Retreat	FC	2	39.5~48.5
		Left	Advance	H	1	30.2~37.2
					2	45.1~55.3
			Retreat	FC	2	39.5~48.5

Differential between LH and RH movement: Less than 5rpm

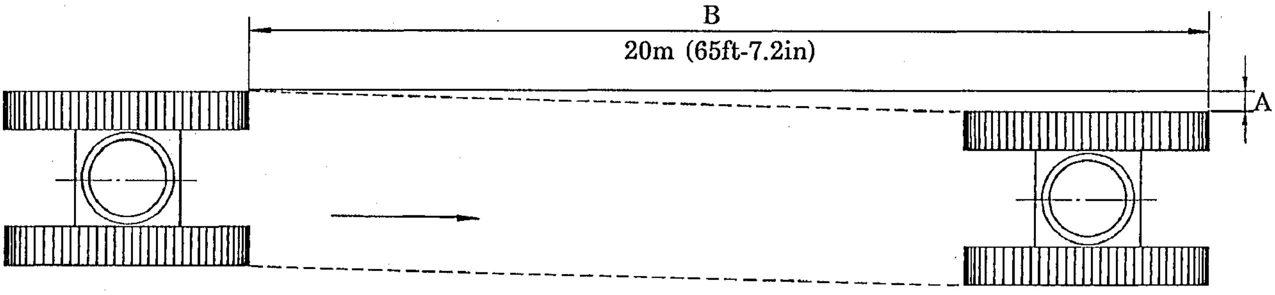


Fig. 35

C. Parking brake

Condition:

Engine stopped, oil temperature of 50±5°C (122±9°F), a slope of 17 degrees.

Procedure:

Leave the machine for one minute with its bucket and arm cylinders fully retracted and with its bucket held at 2m (6ft-7in) above ground, and measure the distance in which the machine moves back in ten minutes.

Table 11 Unit: mm (in)

Symbol	Item	Standard value
C	Parking brake	0

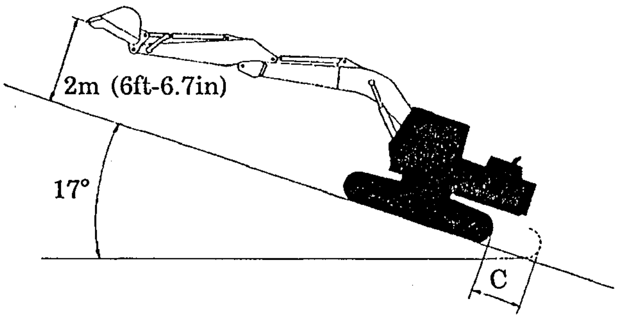


Fig. 36

7. OIL DRAIN FROM MOTORS

A. Swing motor

Condition :

Engine at high idling, oil temperature of 50±5°C (122±9°F).

Procedure :

With the swing locked, measure the drain for one minute, with the hydraulic system in relief state.

B. Travel Motor

Condition :

Engine at high idling, oil temperature of 50±5°C (122±9°F).

Procedure :

With the travel motor locked, measure the drain for one minute, with the hydraulic system in relief state.

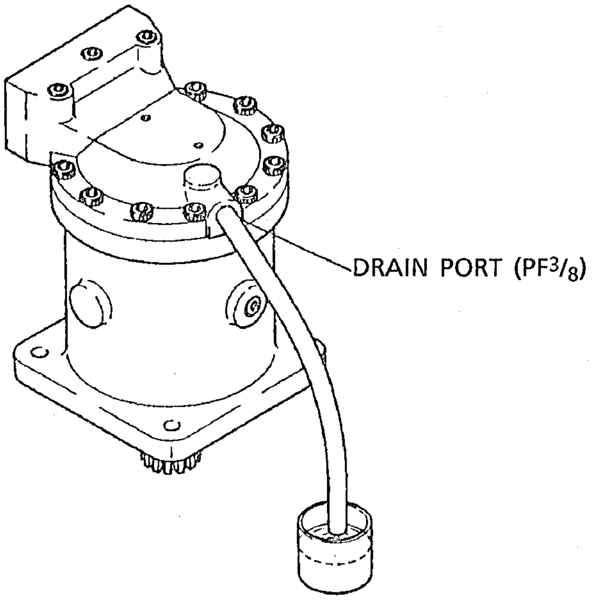


Fig. 37

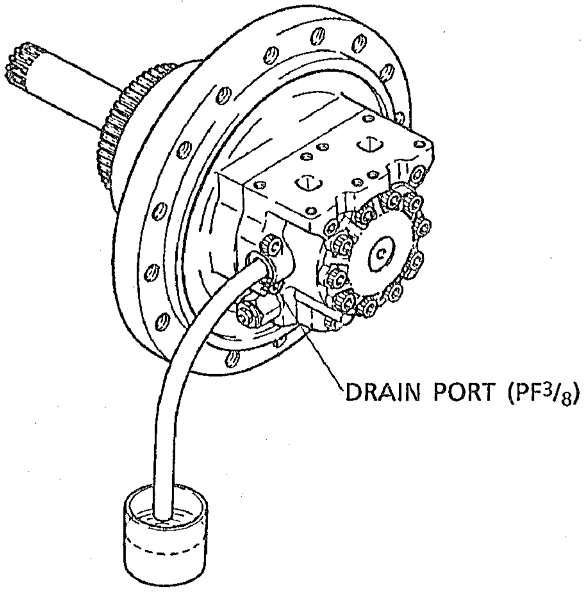


Fig. 38

Table 12 Unit : ℓ/min (gal/min)

Symbol	Item	Standard value	Allowable value	Remedy
A	Drain of swing motor	Max. 3 (0.8)	Max. 10 (2.6)	Overhaul
B	Drain of travel motor	Max. 4 (1.1)	Max, 8 (2.1)	Overhaul

8. PLAY OF SWING BEARING

A. Axial play of swing bearing
After bringing the arm to an upright position, press the attachment against the ground till the front of the crawler takes off the ground 〔posture (I)〕, and fully contract the bucket cylinder and the arm cylinder till the bucket takes off the ground posture (II). Measure the axial displacement of the bearing outer race at the location of the bearing mounting capscrew, using a dial indicator.

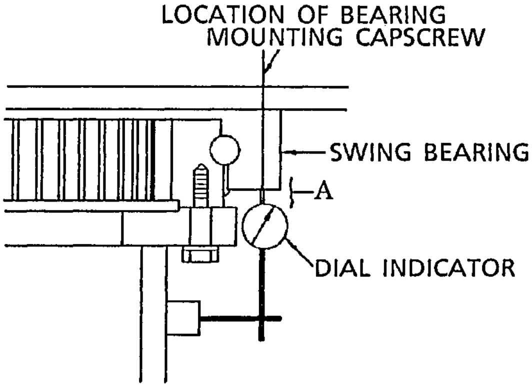


Fig. 39

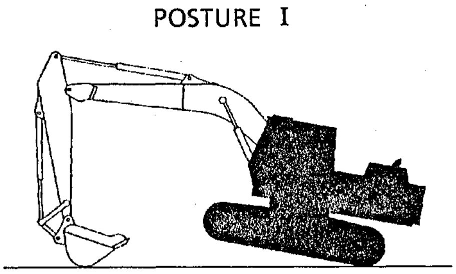


Fig. 40

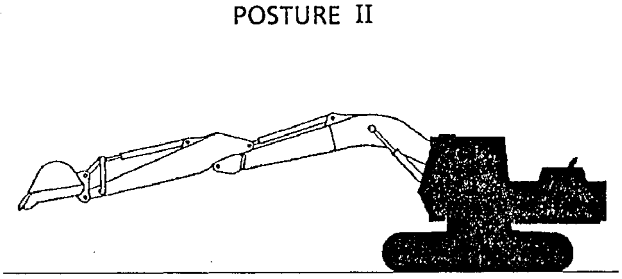


Fig. 41

B. Play between upper and lower bodies on the periphery of swing bearing
Fully contract the arm cylinder and the bucket cylinder and allow the bucket to take off the ground about 10mm (0.4in). Swing the top of the bucket horizontally and measure the travel at the top end of the bucket.

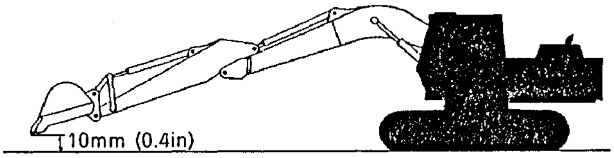


Fig. 42

Table 20 Unit: mm (ft-in)

Symbol	Item	Standard value	Allowable value	Remedy
A	Axial play of swing bearing	0.5~1.5 (0.02~0.06)	2.0 (0.08)	Replace.
B	Horizontal travel at top end of bucket	18~47 (0.7~1.9)	95 (3.7)	

BooK code No. S5LE0505E①

KOBELCO

SHOP MANUAL SK60

TROUBLESHOOTING

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KOBE STEEL, LTD.

Applicable machines
LE-11001~

Revision	Date of issue	Remarks
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1. INTRODUCTION

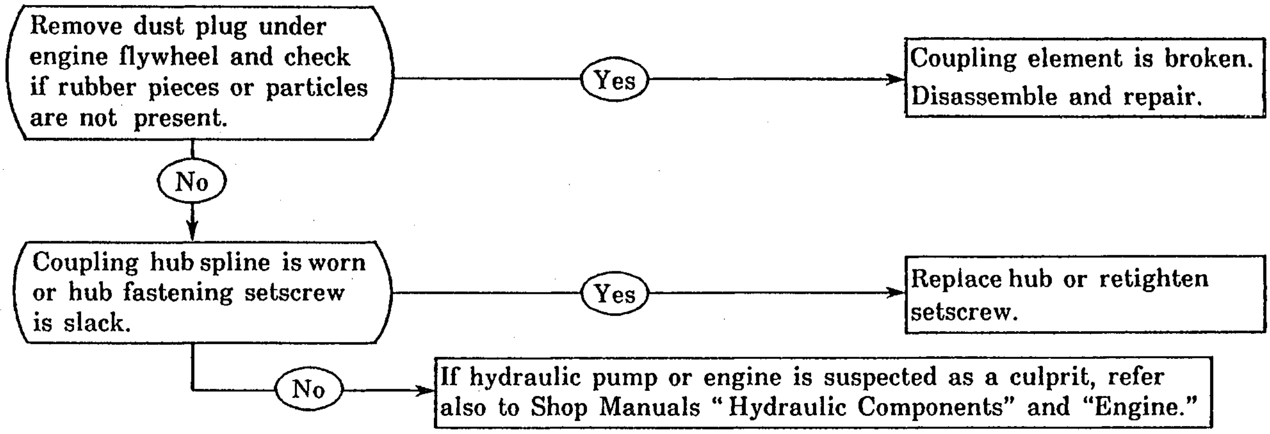
1.1 MACHINE IN GENERAL

(1) If even a minor fault is left intact and operation is continued, a fatal failure may be caused, entailing a large sum of expenses and long hours of restoration. Therefore when even a small trouble occurs, do not rely on your intuition and experience, but look for the cause based on the troubleshooting principle and perform maintenance and adjustment to prevent major failure from occurring. Keep in mind that a fault results from a combination of different causes.

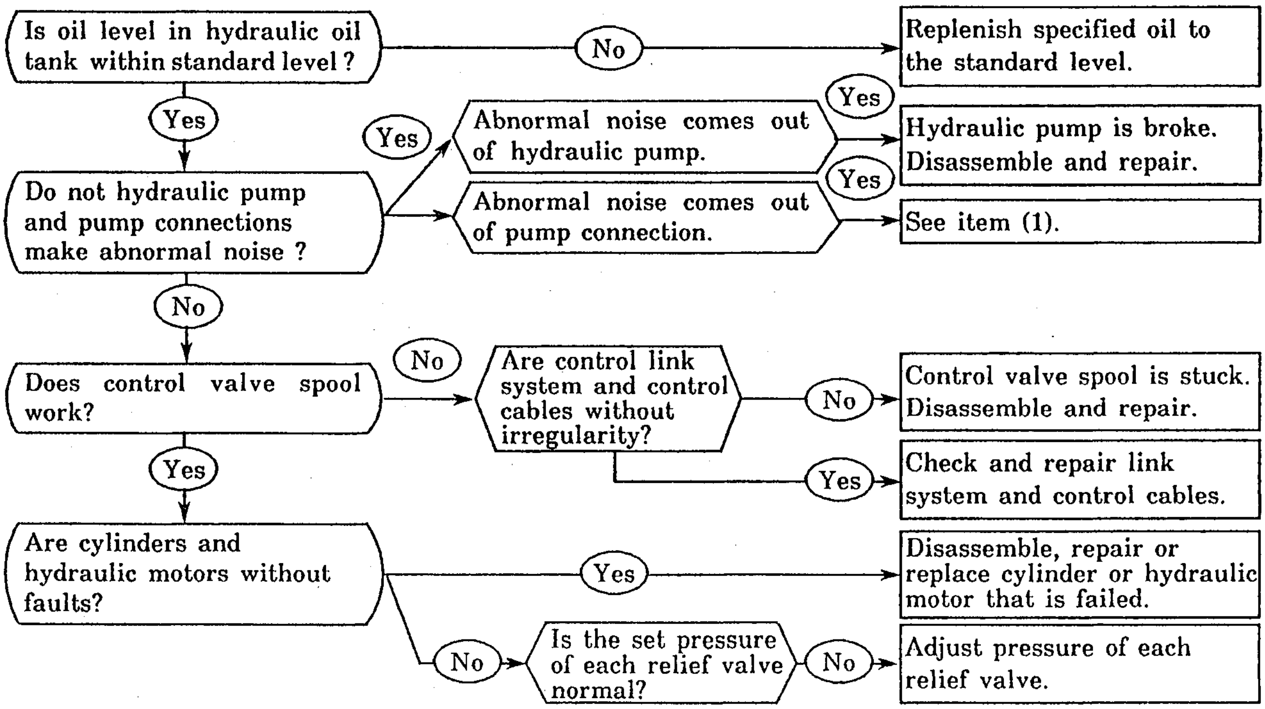
(2) The following lists up commonly occurring faults and possible causes with this machine. For the troubleshooting of the engine, refer to the Shop Manual—Engine. For the troubleshooting of hydraulic components, refer to a separate Shop Manual—Hydraulic Components.

2. DRIVE SYSTEM

(1) Unusual noise comes out of pump connection.

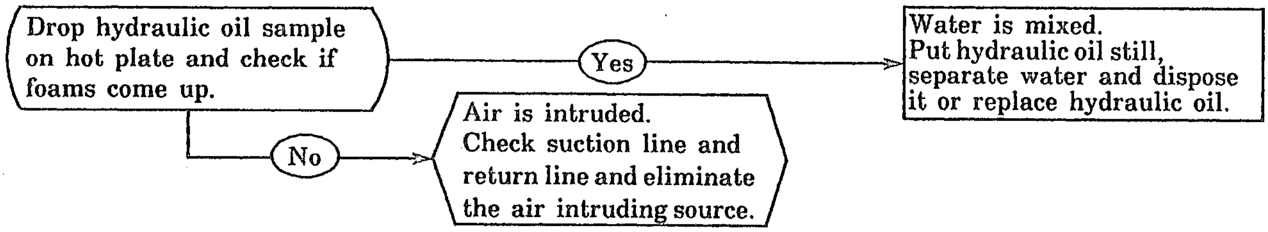

Remove dust plug under engine flywheel and check if rubber pieces or particles are not present.
Yes
Coupling element is broken. Disassemble and repair.
No
Coupling hub spline is worn or hub fastening setscrew is slack.
Yes
Replace hub or retighten setscrew.
No
If hydraulic pump or engine is suspected as a culprit, refer also to Shop Manuals " Hydraulic Components" and "Engine."

(2) Engine starts but machine does not operate at all.


Is oil level in hydraulic oil tank within standard level ?
No
Replenish specified oil to the standard level.
Yes
Do not hydraulic pump and pump connections make abnormal noise ?
Yes
Abnormal noise comes out of hydraulic pump.
Yes
Hydraulic pump is broke. Disassemble and repair.
Abnormal noise comes out of pump connection.
Yes
See item (1).
No
Does control valve spool work?
No
Are control link system and control cables without irregularity?
No
Control valve spool is stuck. Disassemble and repair.
Yes
Check and repair link system and control cables.
Yes
Are cylinders and hydraulic motors without faults?
Yes
Disassemble, repair or replace cylinder or hydraulic motor that is failed.
No
Is the set pressure of each relief valve normal?
No
Adjust pressure of each relief valve.

3. HYDRAULIC SYSTEM

(1) Hydraulic oil is cloudy.

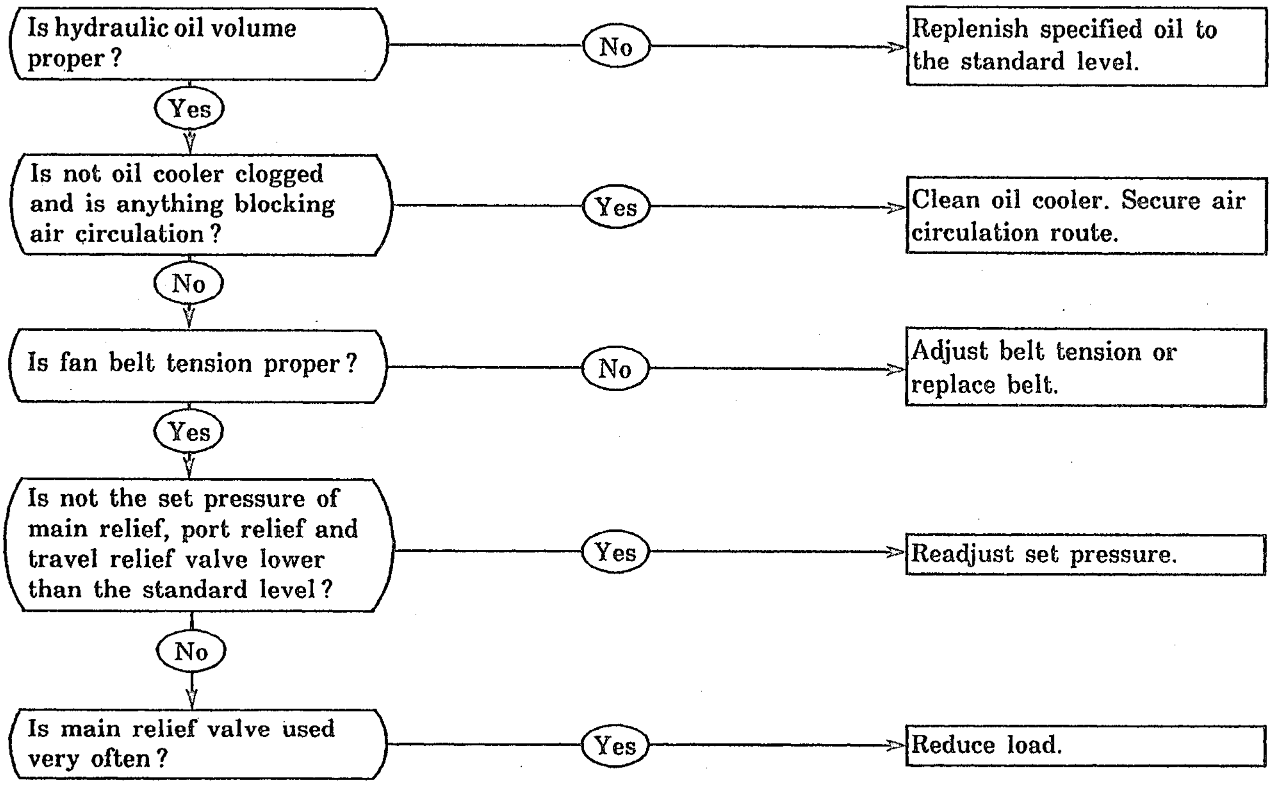


Drop hydraulic oil sample on hot plate and check if foams come up.

Yes → Water is mixed. Put hydraulic oil still, separate water and dispose it or replace hydraulic oil.

No → Air is intruded. Check suction line and return line and eliminate the air intruding source.

(2) Hydraulic oil temperature has risen abnormally.



Is hydraulic oil volume proper?

No → Replenish specified oil to the standard level.

Yes

Is not oil cooler clogged and is anything blocking air circulation?

Yes → Clean oil cooler. Secure air circulation route.

No

Is fan belt tension proper?

No → Adjust belt tension or replace belt.

Yes

Is not the set pressure of main relief, port relief and travel relief valve lower than the standard level?

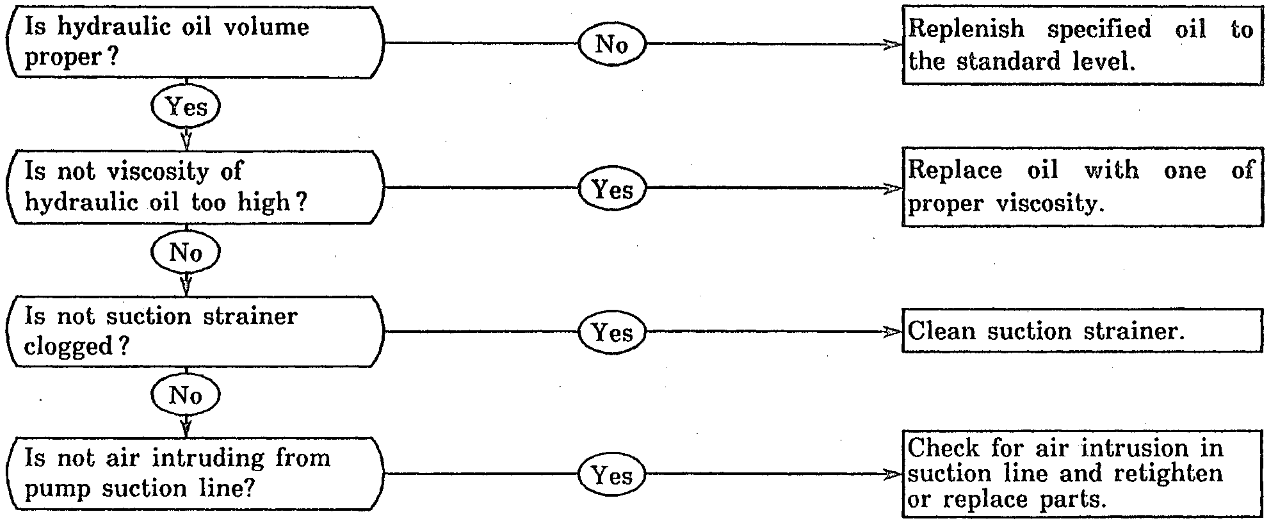
Yes → Readjust set pressure.

No

Is main relief valve used very often?

Yes → Reduce load.

(3) Cavitation occurs with pump.



Is hydraulic oil volume proper?

No → Replenish specified oil to the standard level.

Yes

Is not viscosity of hydraulic oil too high?

Yes → Replace oil with one of proper viscosity.

No

Is not suction strainer clogged?

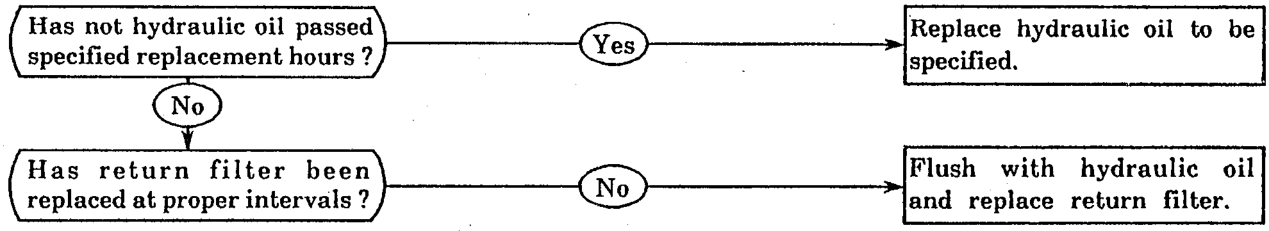
Yes → Clean suction strainer.

No

Is not air intruding from pump suction line?

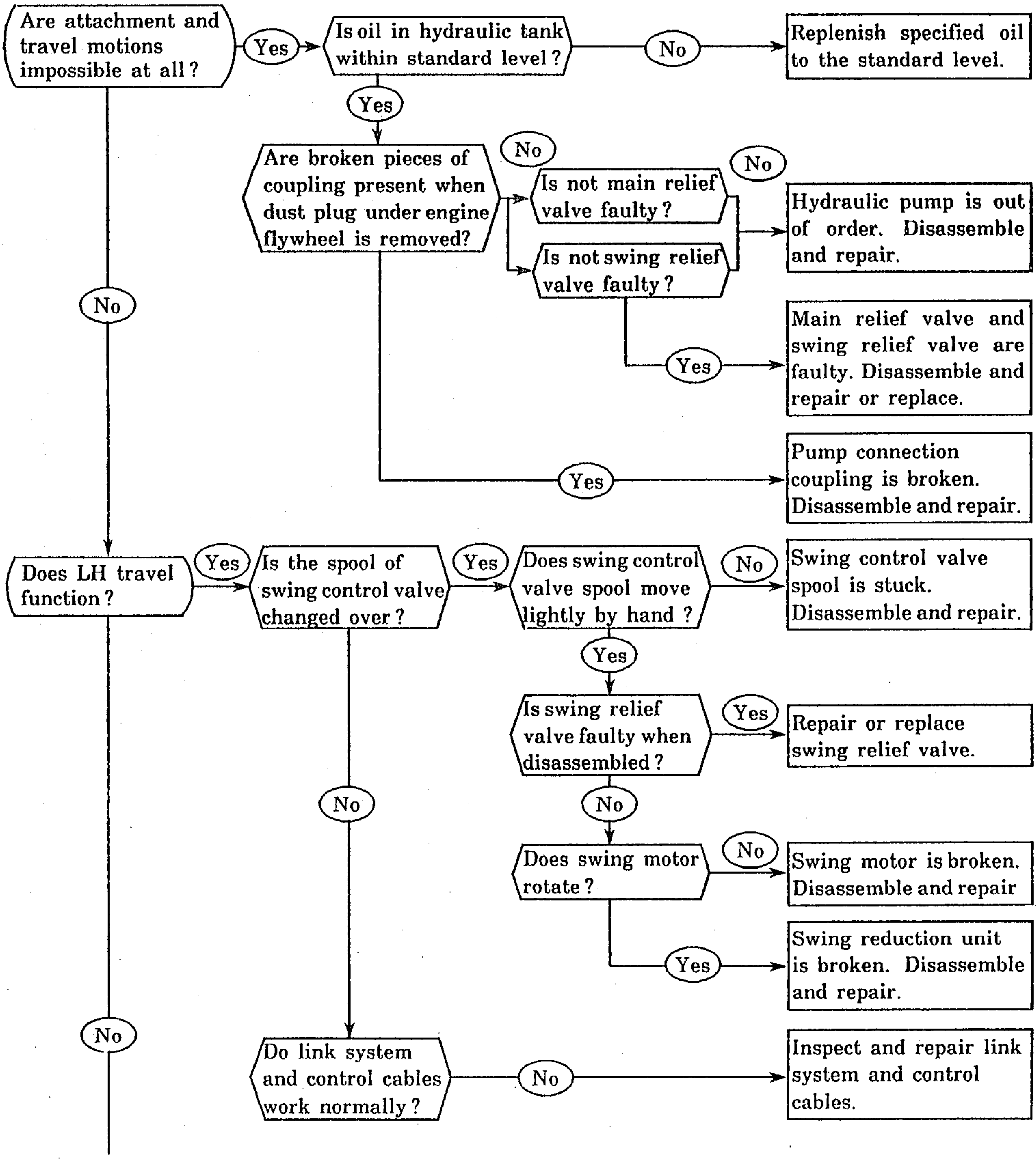
Yes → Check for air intrusion in suction line and retighten or replace parts.

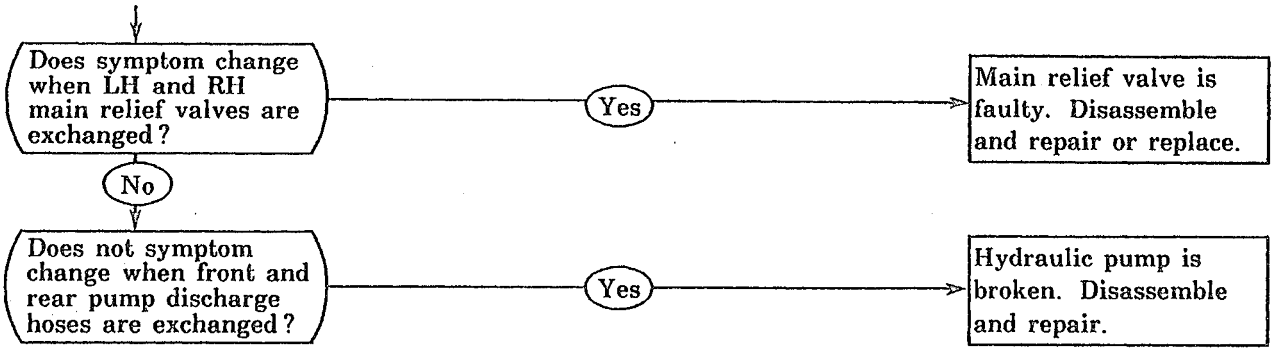
(4) Hydraulic oil is contaminated.


Has not hydraulic oil passed specified replacement hours ?
Yes
Replace hydraulic oil to be specified.
No
Has return filter been replaced at proper intervals ?
No
Flush with hydraulic oil and replace return filter.

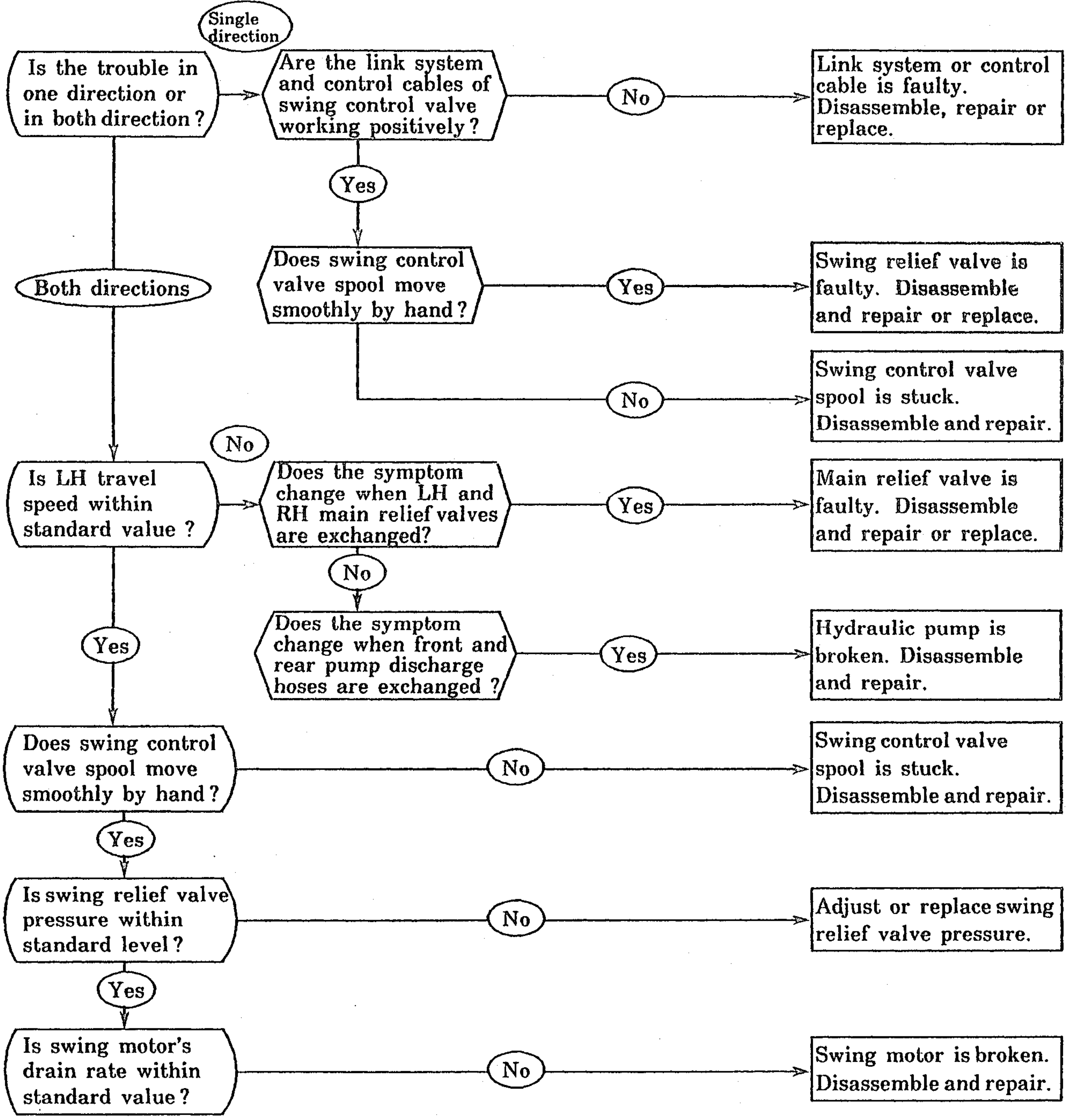
4. SWING SYSTEM

(1) Both LH and RH swing actions are impossible.

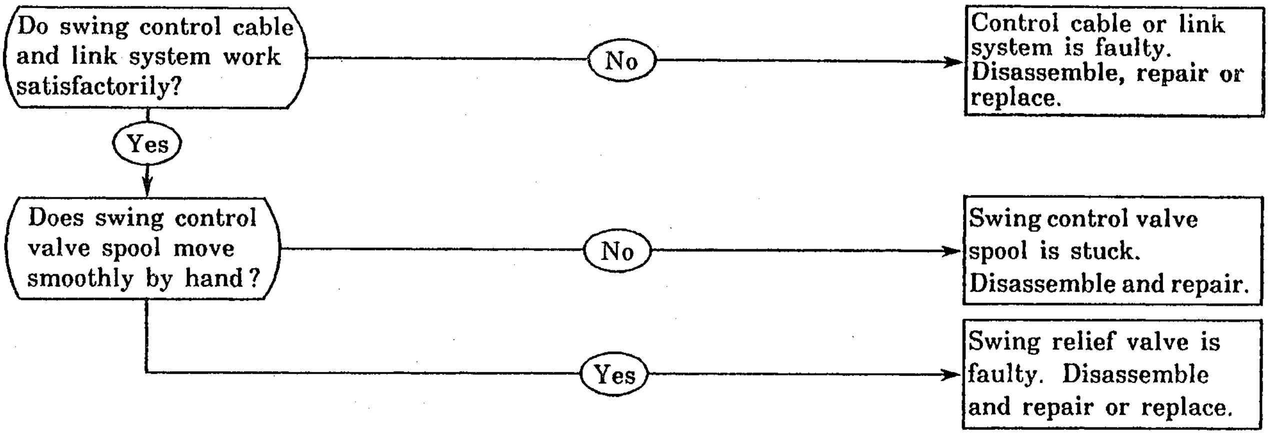

Are attachment and travel motions impossible at all ?
Yes
Is oil in hydraulic tank within standard level ?
No
Replenish specified oil to the standard level.
Yes
Are broken pieces of coupling present when dust plug under engine flywheel is removed?
No
Is not main relief valve faulty ?
No
Is not swing relief valve faulty ?
Hydraulic pump is out of order. Disassemble and repair.
Yes
Main relief valve and swing relief valve are faulty. Disassemble and repair or replace.
Yes
Pump connection coupling is broken. Disassemble and repair.
No
Does LH travel function ?
Yes
Is the spool of swing control valve changed over ?
Yes
Does swing control valve spool move lightly by hand ?
No
Swing control valve spool is stuck. Disassemble and repair.
Yes
Is swing relief valve faulty when disassembled ?
Yes
Repair or replace swing relief valve.
No
No
Does swing motor rotate ?
No
Swing motor is broken. Disassemble and repair
Yes
Swing reduction unit is broken. Disassemble and repair.
No
Do link system and control cables work normally ?
No
Inspect and repair link system and control cables.


Does symptom change when LH and RH main relief valves are exchanged?
Yes
Main relief valve is faulty. Disassemble and repair or replace.
No
Does not symptom change when front and rear pump discharge hoses are exchanged?
Yes
Hydraulic pump is broken. Disassemble and repair.

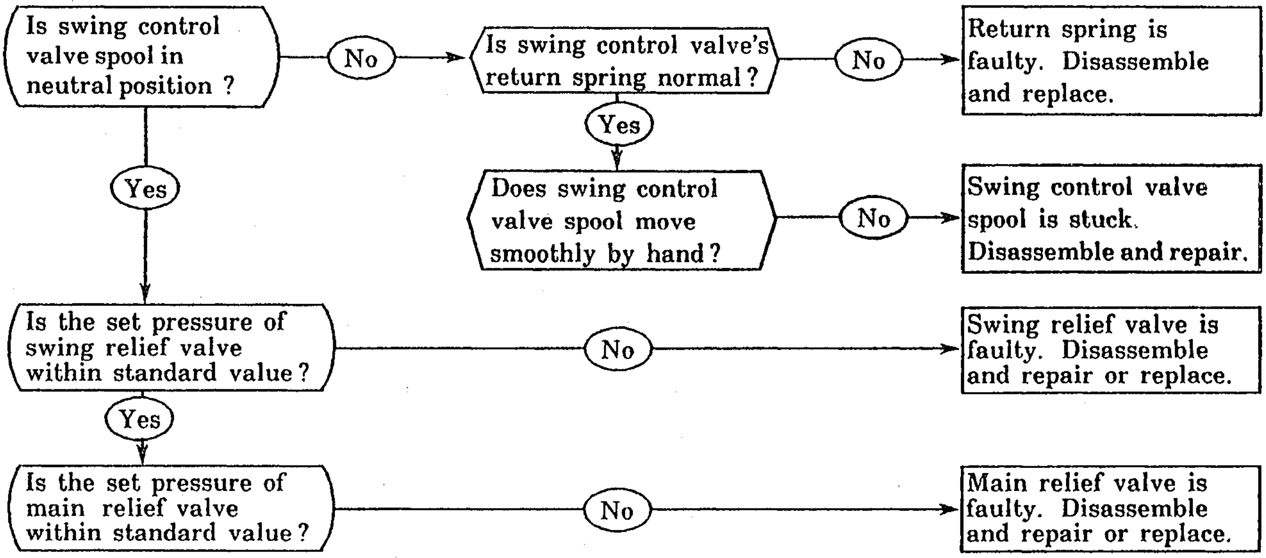
(2) Swing speed is low.


Single direction
Is the trouble in one direction or in both direction?
Are the link system and control cables of swing control valve working positively?
No
Link system or control cable is faulty. Disassemble, repair or replace.
Yes
Does swing control valve spool move smoothly by hand?
Yes
Swing relief valve is faulty. Disassemble and repair or replace.
No
Swing control valve spool is stuck. Disassemble and repair.
Both directions
No
Is LH travel speed within standard value?
Does the symptom change when LH and RH main relief valves are exchanged?
Yes
Main relief valve is faulty. Disassemble and repair or replace.
No
Does the symptom change when front and rear pump discharge hoses are exchanged?
Yes
Hydraulic pump is broken. Disassemble and repair.
Yes
Does swing control valve spool move smoothly by hand?
No
Swing control valve spool is stuck. Disassemble and repair.
Yes
Is swing relief valve pressure within standard level?
No
Adjust or replace swing relief valve pressure.
Yes
Is swing motor's drain rate within standard value?
No
Swing motor is broken. Disassemble and repair.

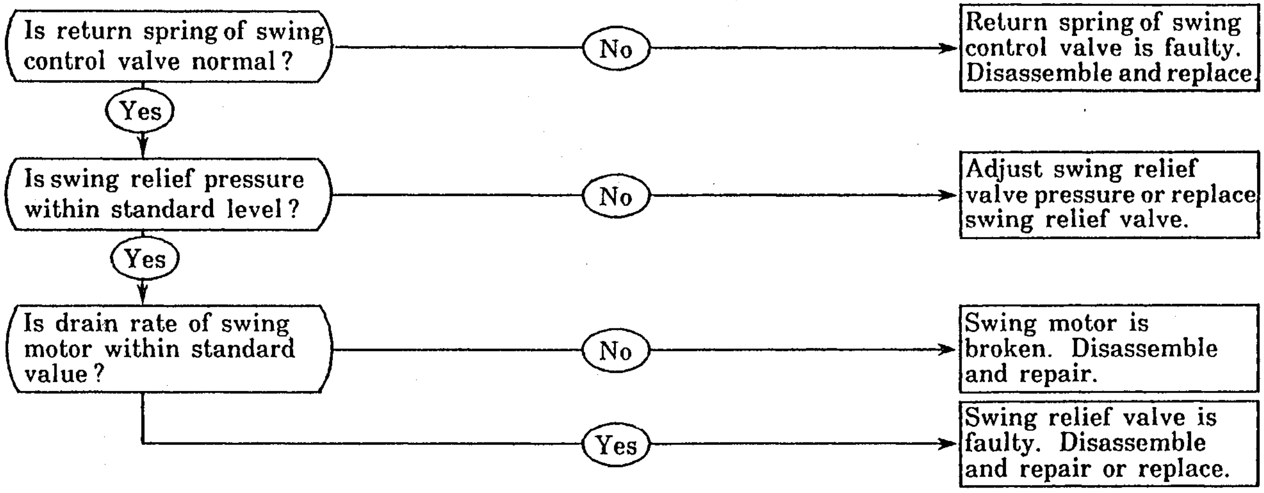
(3) Swing motion is impossible in one direction.


Do swing control cable and link system work satisfactorily?
No
Control cable or link system is faulty. Disassemble, repair or replace.
Yes
Does swing control valve spool move smoothly by hand?
No
Swing control valve spool is stuck. Disassemble and repair.
Yes
Swing relief valve is faulty. Disassemble and repair or replace.

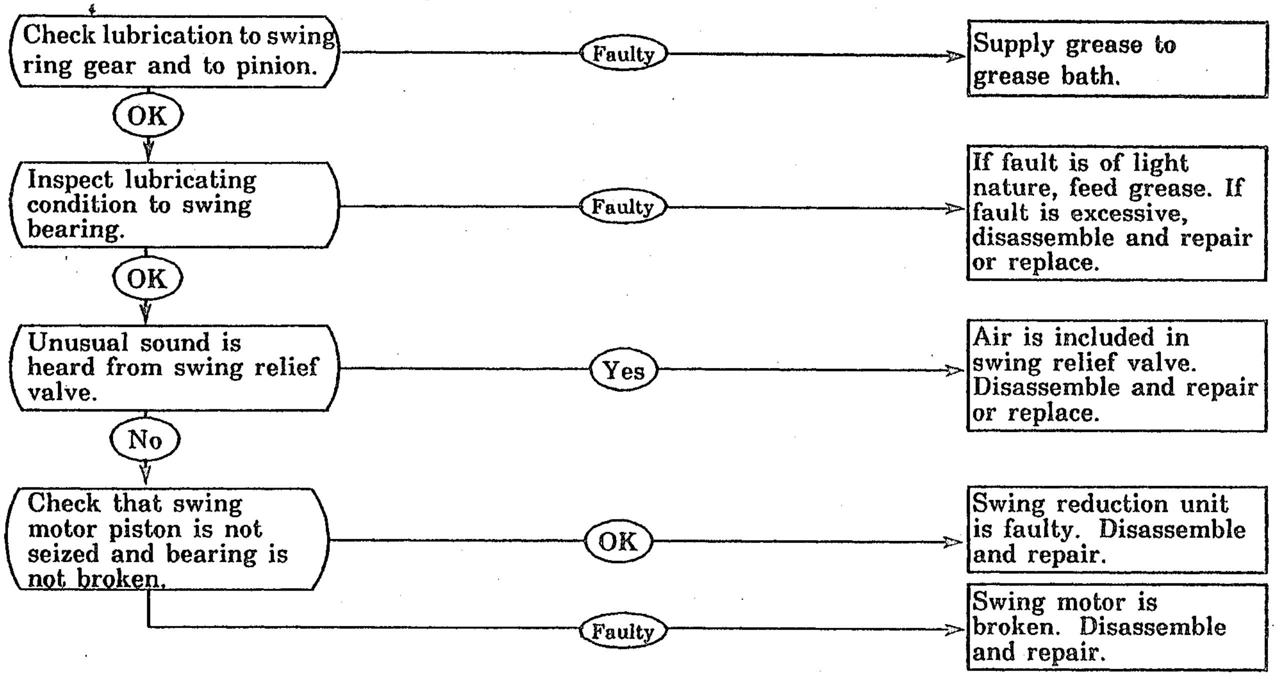
(4) Machine swings but does not stop.


Is swing control valve spool in neutral position ?
No
Is swing control valve's return spring normal ?
No
Return spring is faulty. Disassemble and replace.
Yes
Does swing control valve spool move smoothly by hand?
No
Swing control valve spool is stuck. Disassemble and repair.
Yes
Is the set pressure of swing relief valve within standard value ?
No
Swing relief valve is faulty. Disassemble and repair or replace.
Yes
Is the set pressure of main relief valve within standard value ?
No
Main relief valve is faulty. Disassemble and repair or replace.

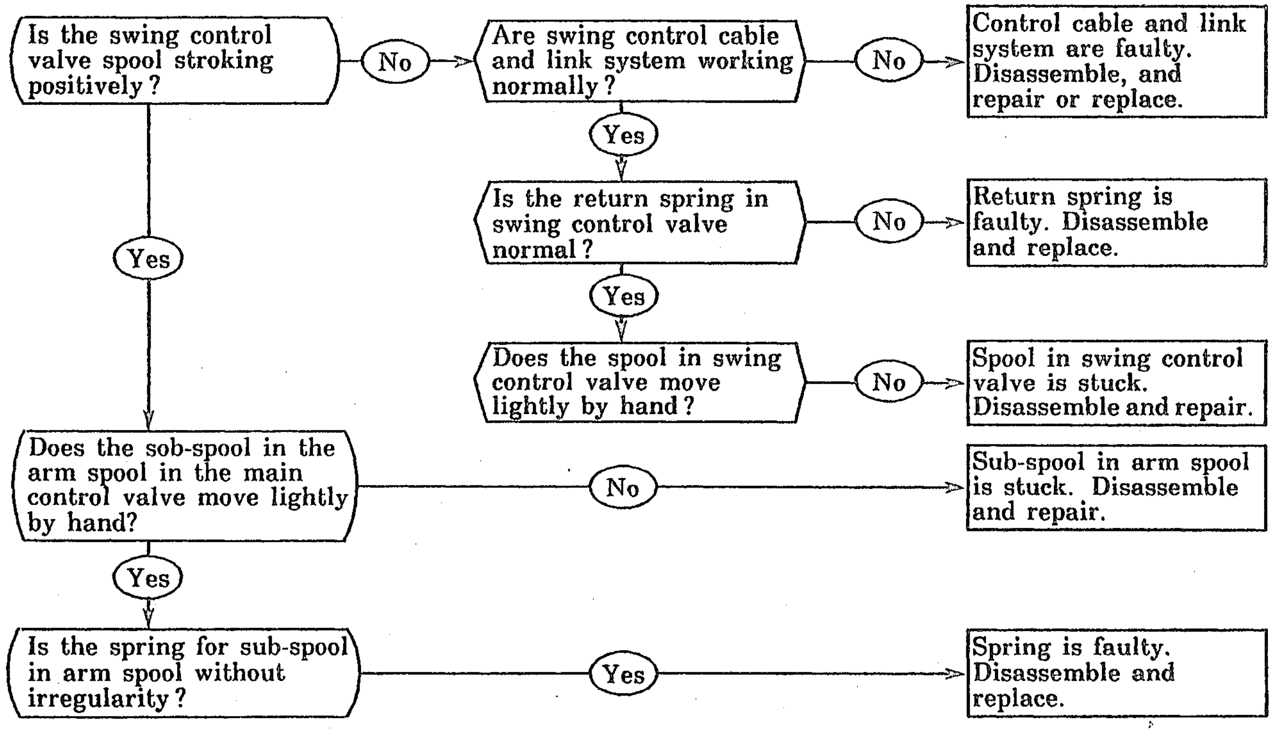
(5) The swing unit drifts when the machine is at rest on a slope.


Is return spring of swing control valve normal ?
No
Return spring of swing control valve is faulty. Disassemble and replace.
Yes
Is swing relief pressure within standard level ?
No
Adjust swing relief valve pressure or replace swing relief valve.
Yes
Is drain rate of swing motor within standard value ?
No
Swing motor is broken. Disassemble and repair.
Yes
Swing relief valve is faulty. Disassemble and repair or replace.

(6) Abnormal noise is heard in swing motion.

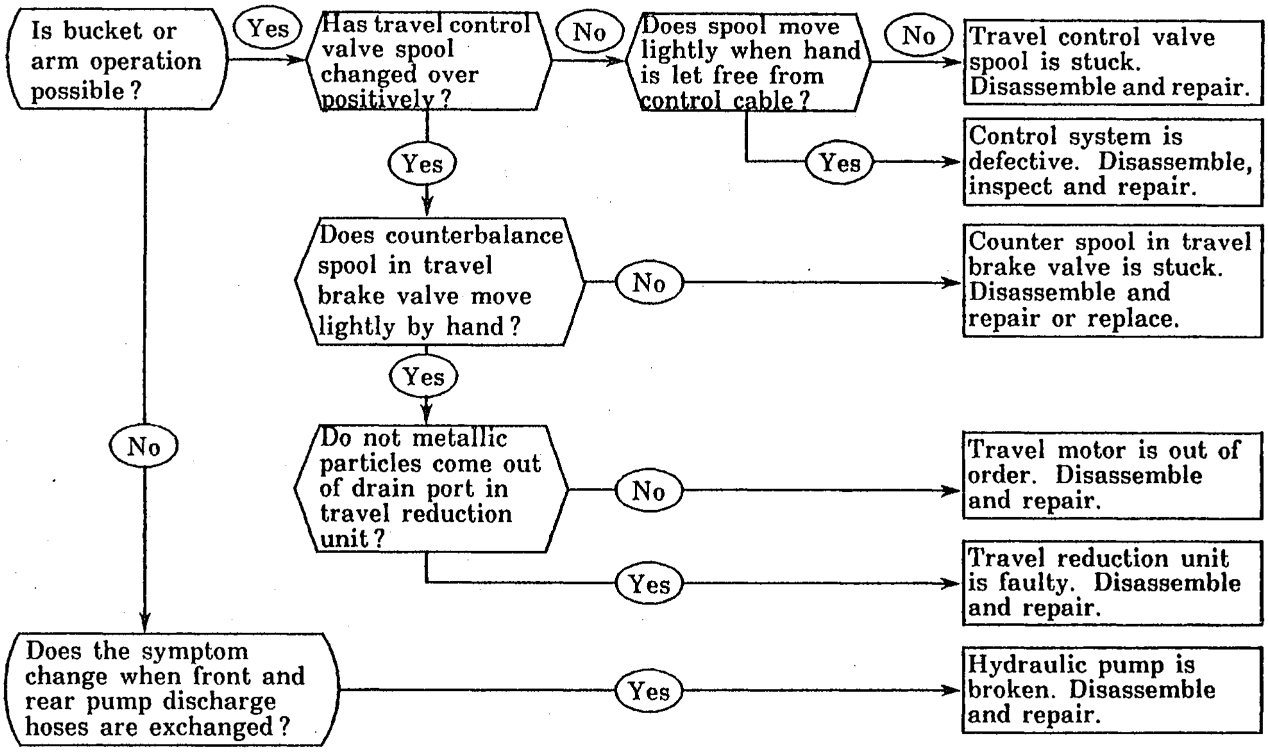

Check lubrication to swing ring gear and to pinion.
Faulty
Supply grease to grease bath.
OK
Inspect lubricating condition to swing bearing.
Faulty
If fault is of light nature, feed grease. If fault is excessive, disassemble and repair or replace.
OK
Unusual sound is heard from swing relief valve.
Yes
Air is included in swing relief valve. Disassemble and repair or replace.
No
Check that swing motor piston is not seized and bearing is not broken.
OK
Swing reduction unit is faulty. Disassemble and repair.
Faulty
Swing motor is broken. Disassemble and repair.

(7) Swing preferential function does not work.

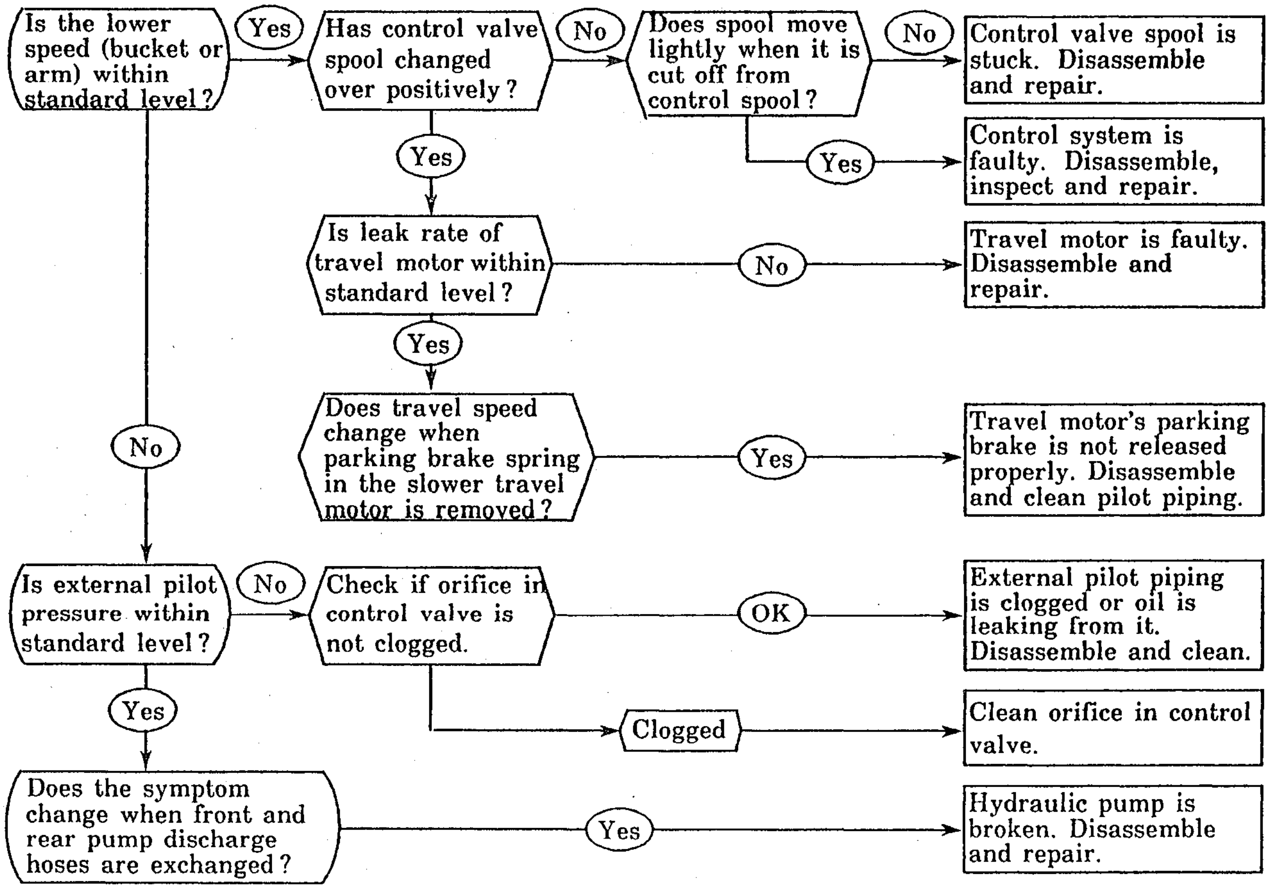

Is the swing control valve spool stroking positively?
No
Are swing control cable and link system working normally?
No
Control cable and link system are faulty. Disassemble, and repair or replace.
Yes
Is the return spring in swing control valve normal?
No
Return spring is faulty. Disassemble and replace.
Yes
Does the spool in swing control valve move lightly by hand?
No
Spool in swing control valve is stuck. Disassemble and repair.
Yes
Does the sob-spool in the arm spool in the main control valve move lightly by hand?
No
Sub-spool in arm spool is stuck. Disassemble and repair.
Yes
Is the spring for sub-spool in arm spool without irregularity?
Yes
Spring is faulty. Disassemble and replace.

5. TRAVEL SYSTEM

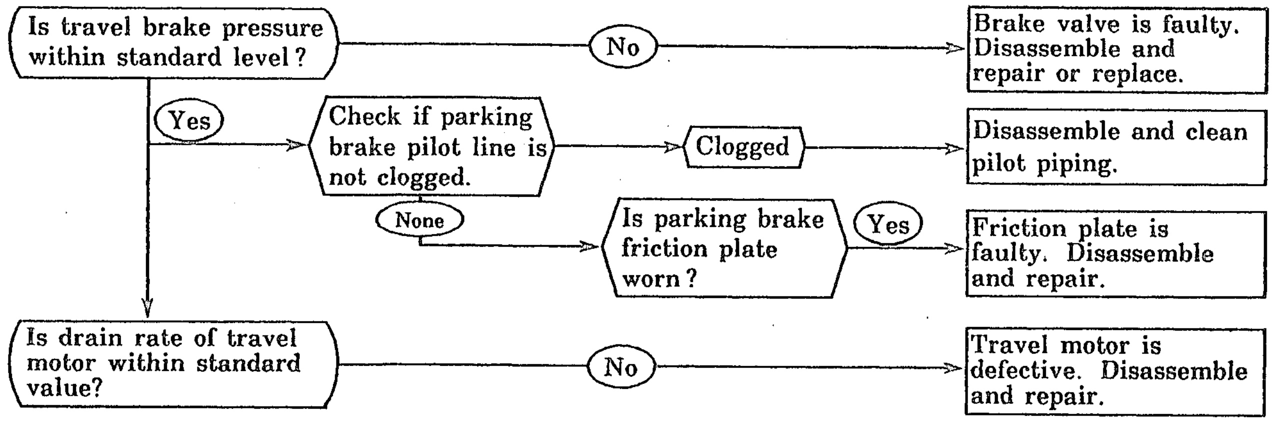
(1) Travel does not function at all on one side.


Is bucket or arm operation possible?
Yes
Has travel control valve spool changed over positively?
No
Does spool move lightly when hand is let free from control cable?
No
Travel control valve spool is stuck. Disassemble and repair.
Yes
Yes
Control system is defective. Disassemble, inspect and repair.
Does counterbalance spool in travel brake valve move lightly by hand?
No
Counter spool in travel brake valve is stuck. Disassemble and repair or replace.
Yes
No
Do not metallic particles come out of drain port in travel reduction unit?
No
Travel motor is out of order. Disassemble and repair.
Yes
Travel reduction unit is faulty. Disassemble and repair.
Does the symptom change when front and rear pump discharge hoses are exchanged?
Yes
Hydraulic pump is broken. Disassemble and repair.

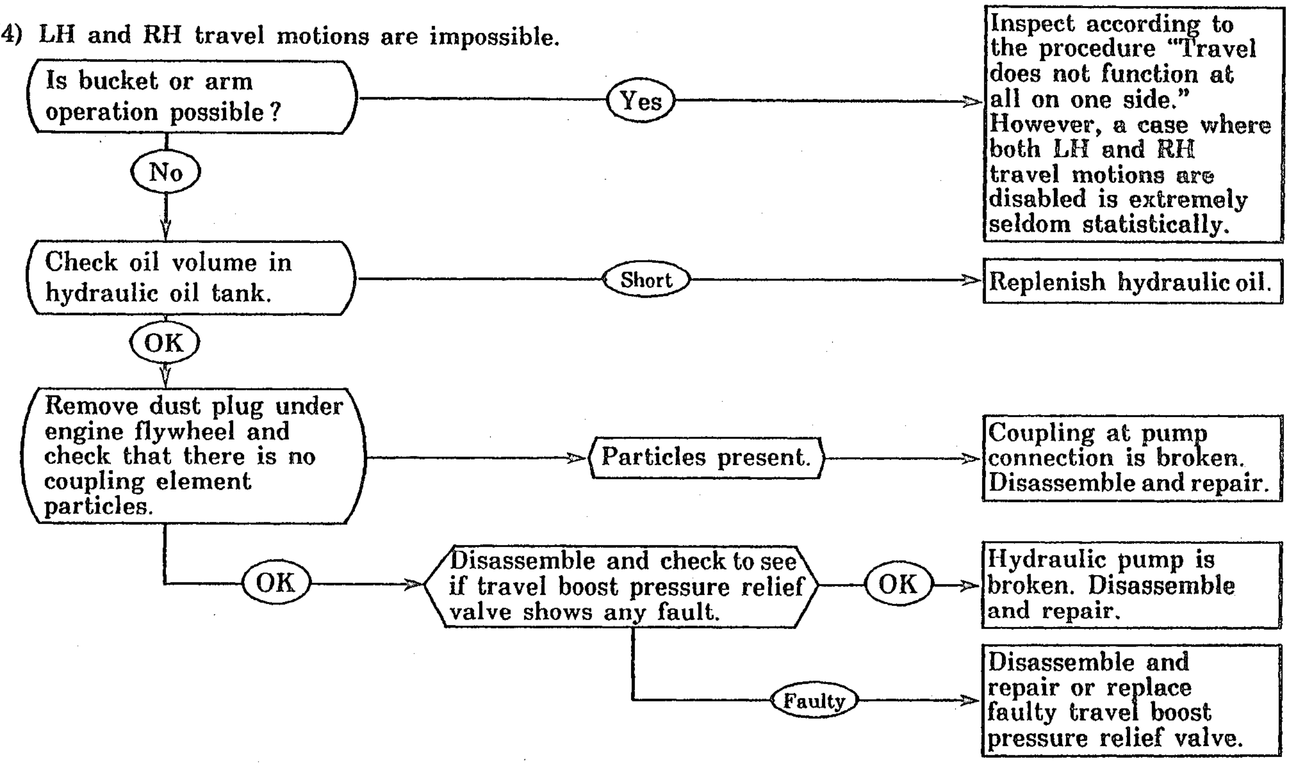
(2) Speed on one side falls and the machine curves (at single operation).


Is the lower speed (bucket or arm) within standard level?
Yes
Has control valve spool changed over positively?
No
Does spool move lightly when it is cut off from control spool?
No
Control valve spool is stuck. Disassemble and repair.
Yes
Yes
Control system is faulty. Disassemble, inspect and repair.
Is leak rate of travel motor within standard level?
No
Travel motor is faulty. Disassemble and repair.
Yes
No
Does travel speed change when parking brake spring in the slower travel motor is removed?
Yes
Travel motor's parking brake is not released properly. Disassemble and clean pilot piping.
Is external pilot pressure within standard level?
No
Check if orifice in control valve is not clogged.
OK
External pilot piping is clogged or oil is leaking from it. Disassemble and clean.
Clogged
Clean orifice in control valve.
Yes
Does the symptom change when front and rear pump discharge hoses are exchanged?
Yes
Hydraulic pump is broken. Disassemble and repair.

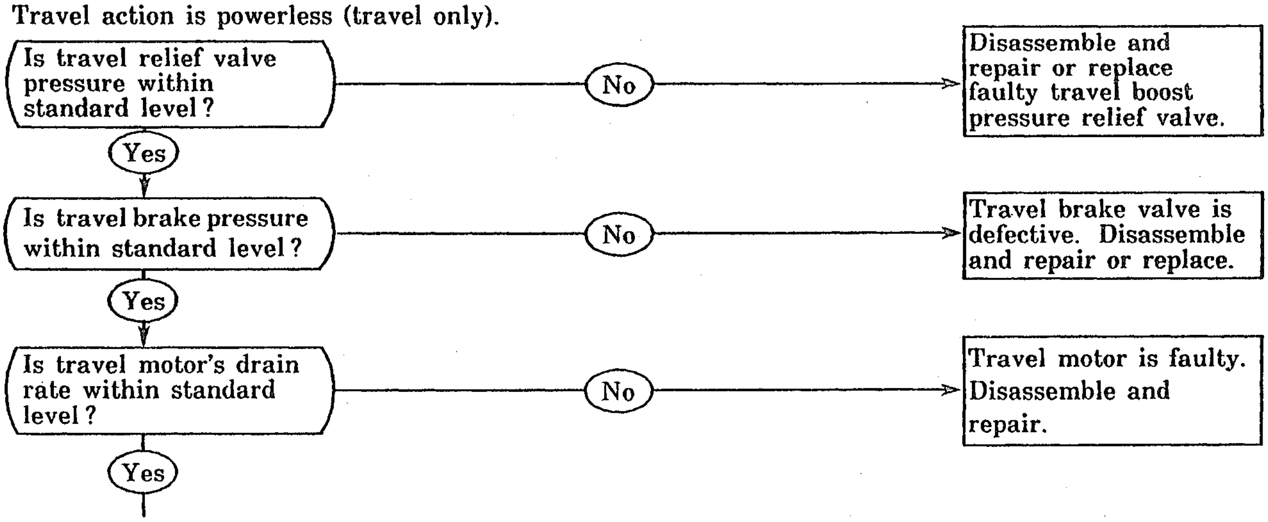
(3) Machine does not stop on a slope. Machine is pulled forward as sprocket rotates during digging operation.

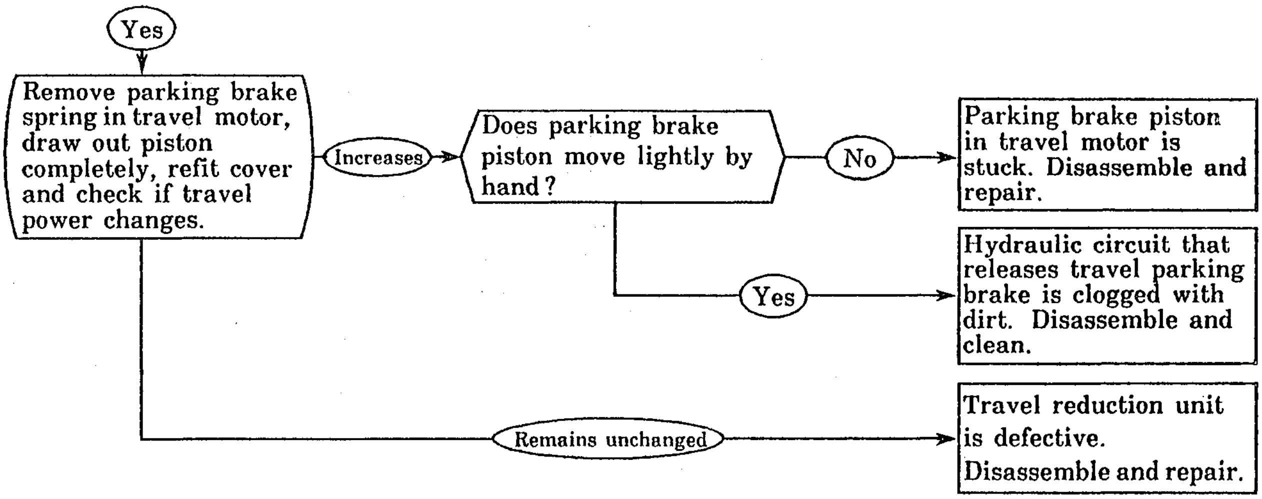

Is travel brake pressure within standard level?
No
Brake valve is faulty. Disassemble and repair or replace.
Yes
Check if parking brake pilot line is not clogged.
Clogged
Disassemble and clean pilot piping.
None
Is parking brake friction plate worn?
Yes
Friction plate is faulty. Disassemble and repair.
Is drain rate of travel motor within standard value?
No
Travel motor is defective. Disassemble and repair.

(4) LH and RH travel motions are impossible.


Is bucket or arm operation possible?
Yes
Inspect according to the procedure "Travel does not function at all on one side." However, a case where both LH and RH travel motions are disabled is extremely seldom statistically.
No
Check oil volume in hydraulic oil tank.
Short
Replenish hydraulic oil.
OK
Remove dust plug under engine flywheel and check that there is no coupling element particles.
Particles present.
Coupling at pump connection is broken. Disassemble and repair.
OK
Disassemble and check to see if travel boost pressure relief valve shows any fault.
OK
Hydraulic pump is broken. Disassemble and repair.
Faulty
Disassemble and repair or replace faulty travel boost pressure relief valve.

(5) Travel action is powerless (travel only).

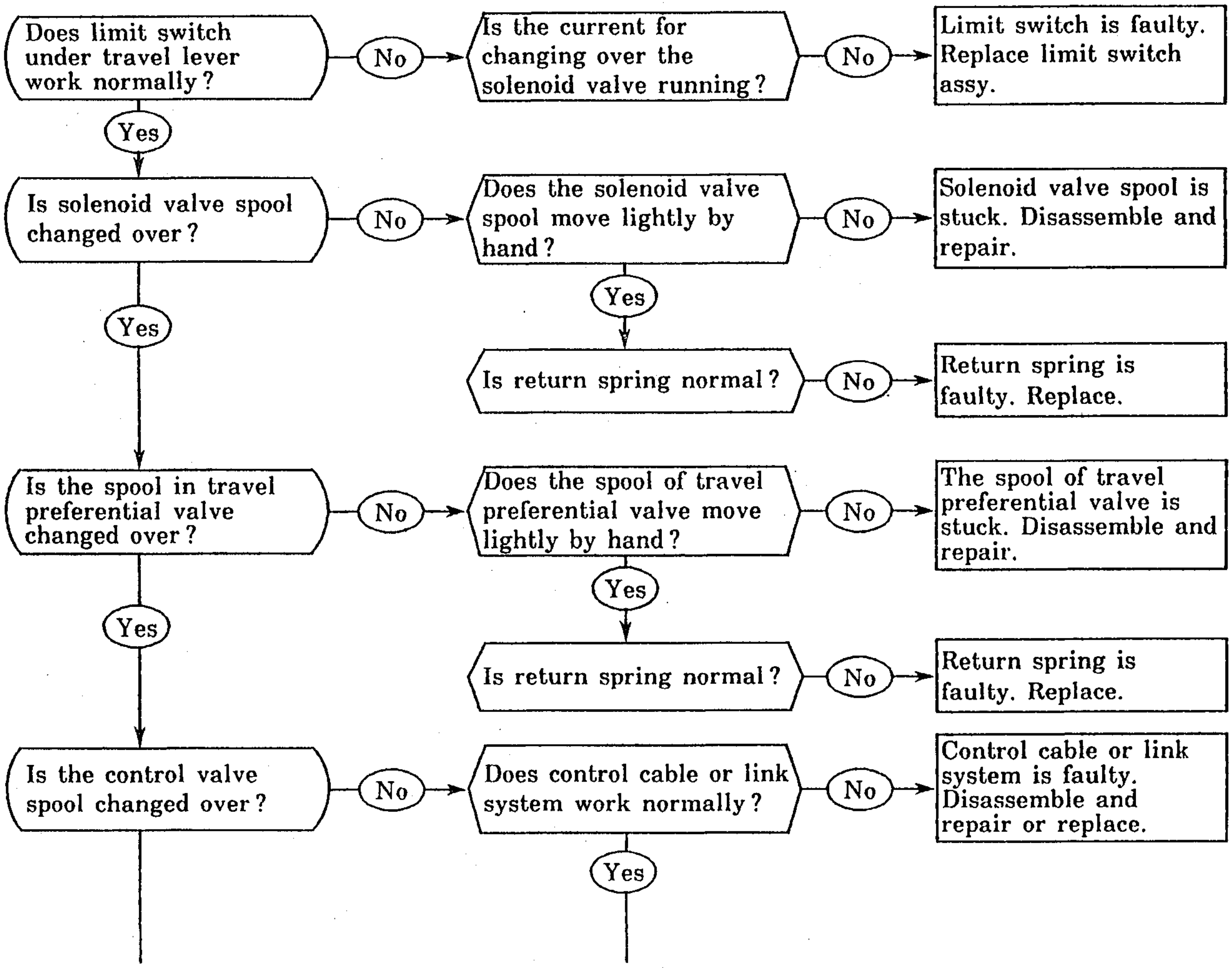

Is travel relief valve pressure within standard level?
No
Disassemble and repair or replace faulty travel boost pressure relief valve.
Yes
Is travel brake pressure within standard level?
No
Travel brake valve is defective. Disassemble and repair or replace.
Yes
Is travel motor's drain rate within standard level?
No
Travel motor is faulty. Disassemble and repair.
Yes

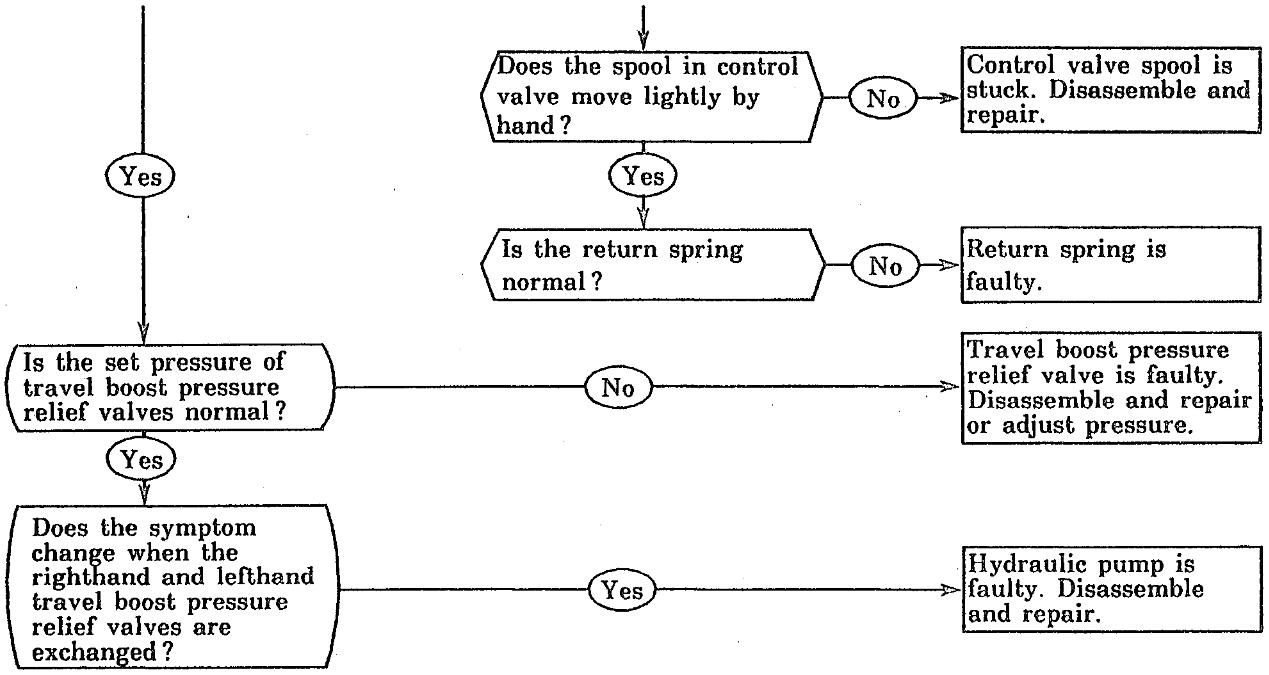

Yes
Remove parking brake spring in travel motor, draw out piston completely, refit cover and check if travel power changes.
Increases
Does parking brake piston move lightly by hand?
No
Parking brake piston in travel motor is stuck. Disassemble and repair.
Yes
Hydraulic circuit that releases travel parking brake is clogged with dirt. Disassemble and clean.
Remains unchanged
Travel reduction unit is defective. Disassemble and repair.

(6) Machine runs recklessly on a slope.

Travel brake valve (counter balance valve) is faulty. Disassemble and repair or replace.

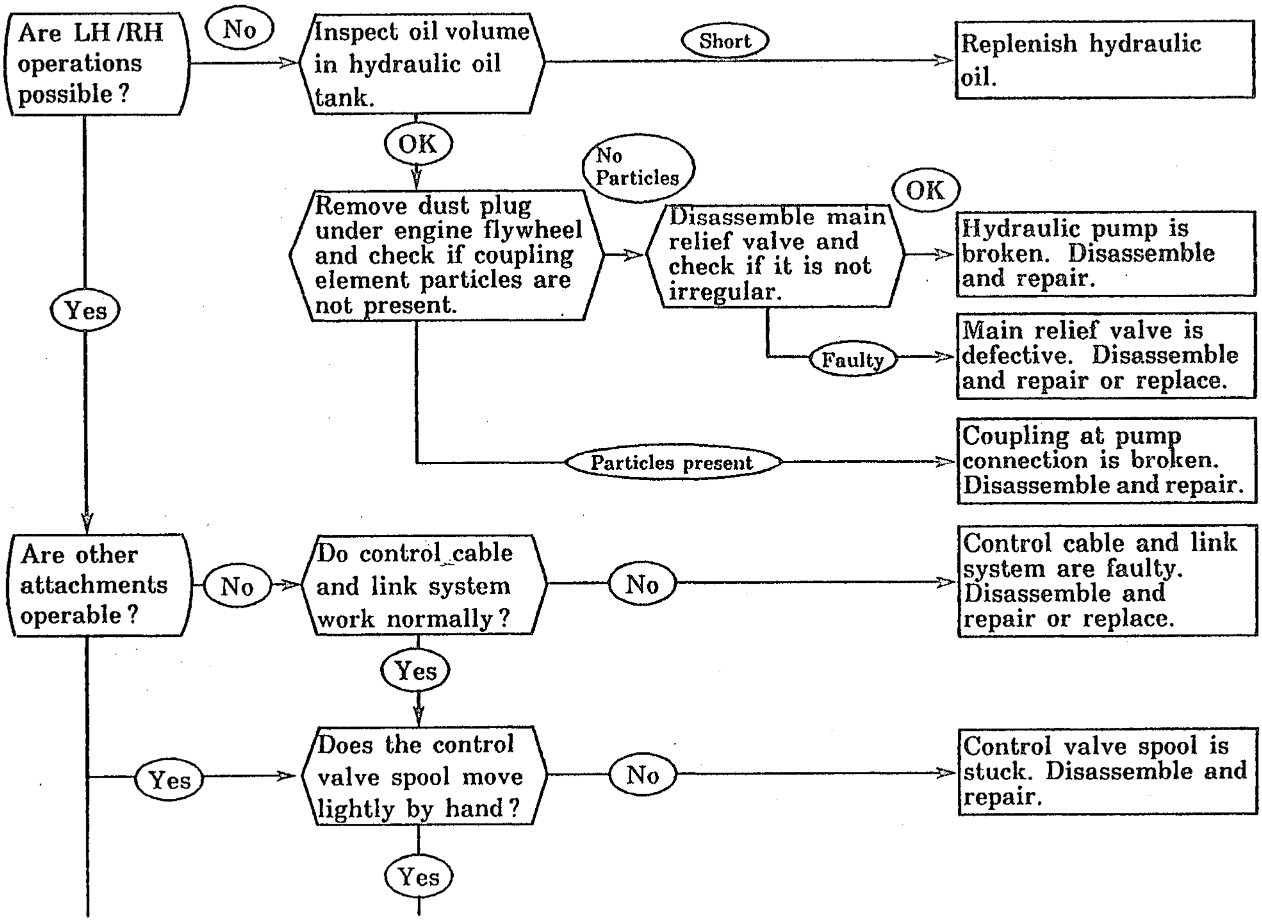
(7) Machine makes a curved travel or does not travel at all when travel and attachment operations are executed at the same time.

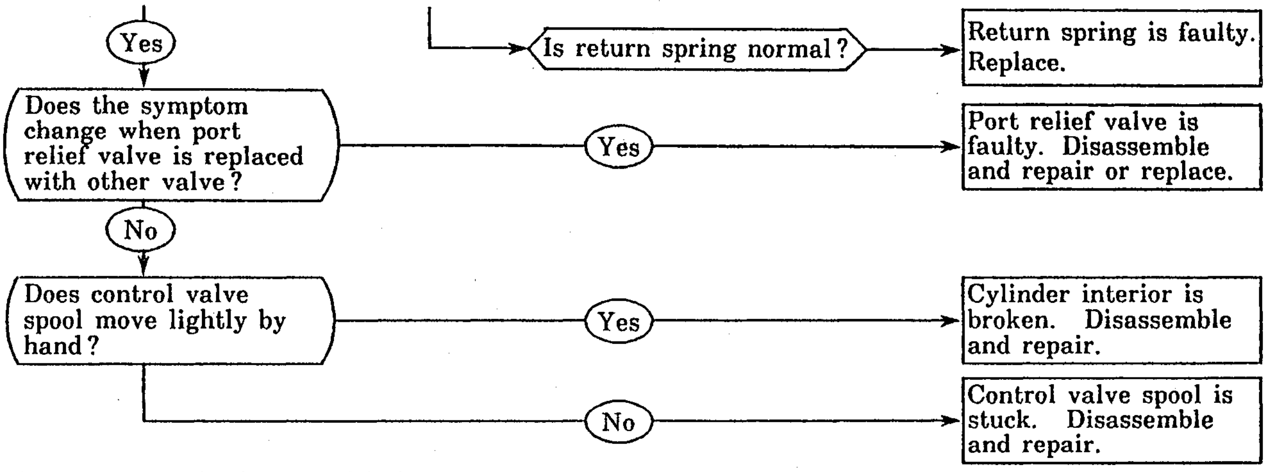

Does limit switch under travel lever work normally?
No
Is the current for changing over the solenoid valve running?
No
Limit switch is faulty. Replace limit switch assy.
Yes
Is solenoid valve spool changed over?
No
Does the solenoid valve spool move lightly by hand?
No
Solenoid valve spool is stuck. Disassemble and repair.
Yes
Is return spring normal?
No
Return spring is faulty. Replace.
Yes
Is the spool in travel preferential valve changed over?
No
Does the spool of travel preferential valve move lightly by hand?
No
The spool of travel preferential valve is stuck. Disassemble and repair.
Yes
Is return spring normal?
No
Return spring is faulty. Replace.
Yes
Is the control valve spool changed over?
No
Does control cable or link system work normally?
No
Control cable or link system is faulty. Disassemble and repair or replace.
Yes


Does the spool in control valve move lightly by hand?
No
Control valve spool is stuck. Disassemble and repair.
Yes
Is the return spring normal?
No
Return spring is faulty.
Yes
Is the set pressure of travel boost pressure relief valves normal?
No
Travel boost pressure relief valve is faulty. Disassemble and repair or adjust pressure.
Yes
Does the symptom change when the righthand and lefthand travel boost pressure relief valves are exchanged?
Yes
Hydraulic pump is faulty. Disassemble and repair.

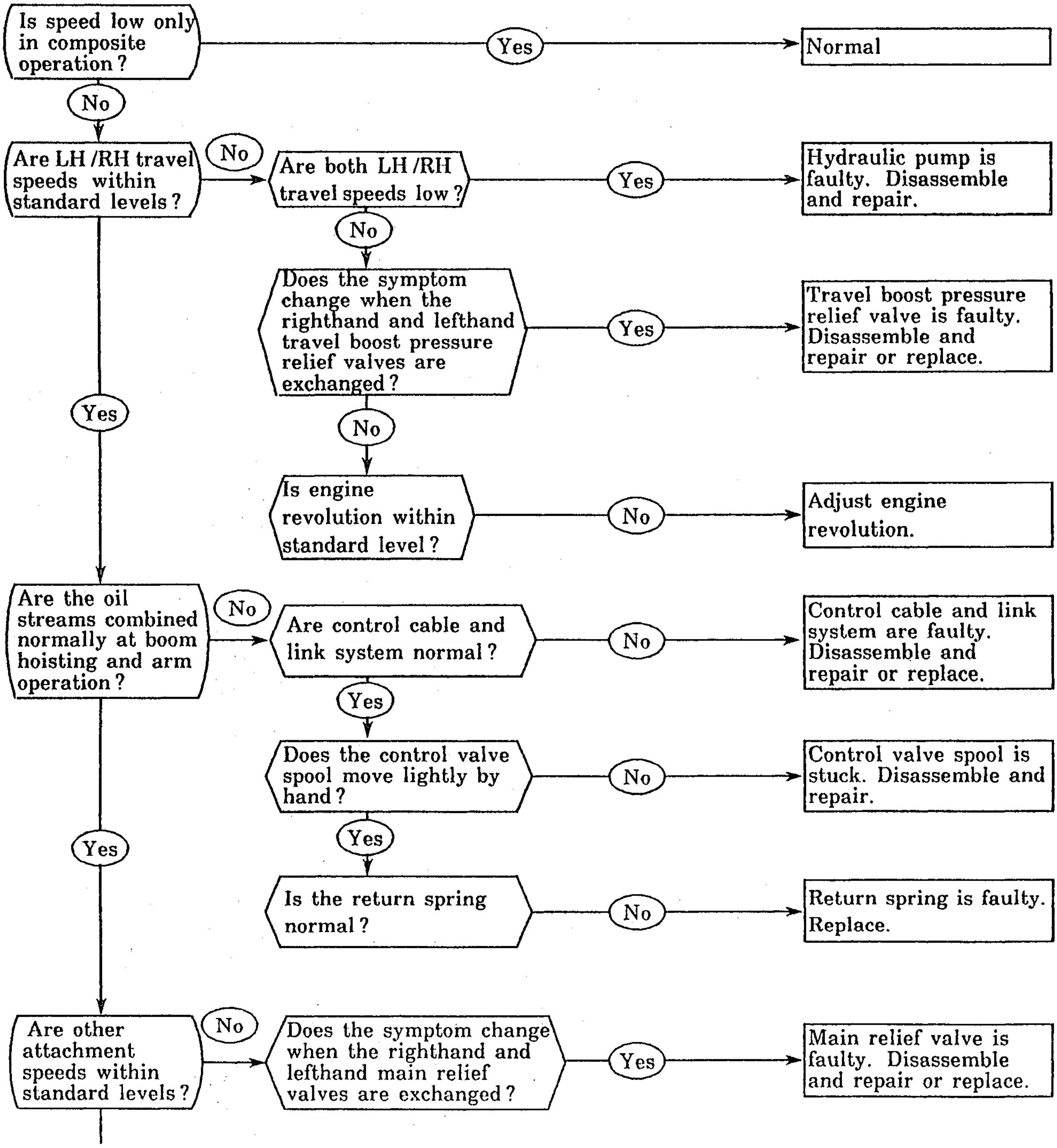
6. ATTACHMENT SYSTEM

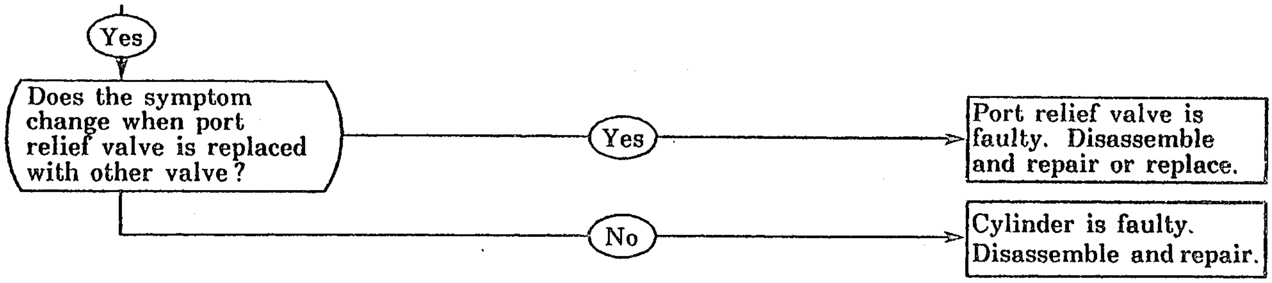
(1) Boom or arm action is impossible at all.


Are LH/RH operations possible?
No
Inspect oil volume in hydraulic oil tank.
Short
Replenish hydraulic oil.
OK
Remove dust plug under engine flywheel and check if coupling element particles are not present.
No Particles
Disassemble main relief valve and check if it is not irregular.
OK
Hydraulic pump is broken. Disassemble and repair.
Faulty
Main relief valve is defective. Disassemble and repair or replace.
Particles present
Coupling at pump connection is broken. Disassemble and repair.
Yes
Are other attachments operable?
No
Do control cable and link system work normally?
No
Control cable and link system are faulty. Disassemble and repair or replace.
Yes
Yes
Does the control valve spool move lightly by hand?
No
Control valve spool is stuck. Disassemble and repair.
Yes

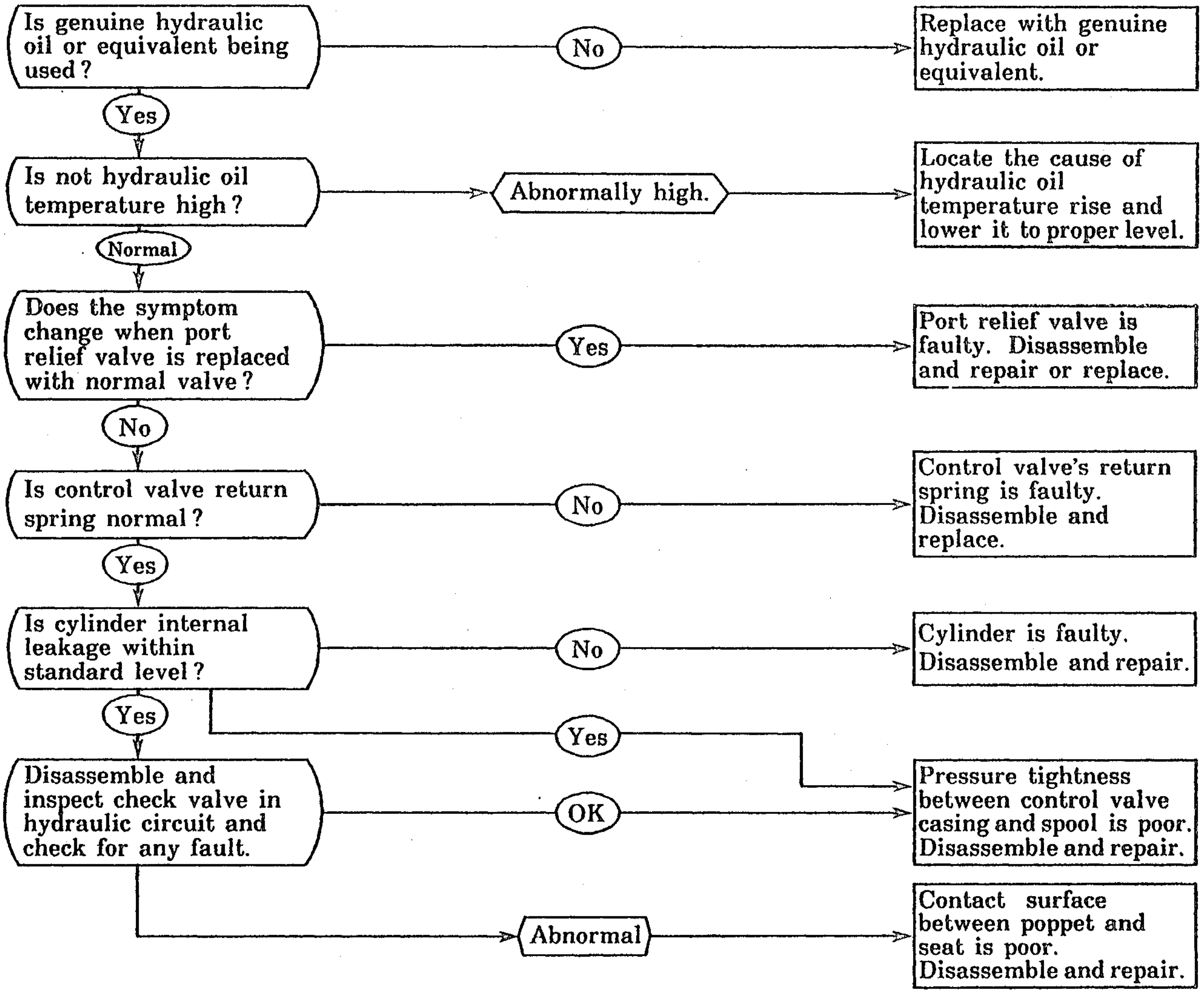

Yes
Is return spring normal?
Return spring is faulty. Replace.
Does the symptom change when port relief valve is replaced with other valve?
Yes
Port relief valve is faulty. Disassemble and repair or replace.
No
Does control valve spool move lightly by hand?
Yes
Cylinder interior is broken. Disassemble and repair.
No
Control valve spool is stuck. Disassemble and repair.

(2) Boom, arm or bucket speed is low.

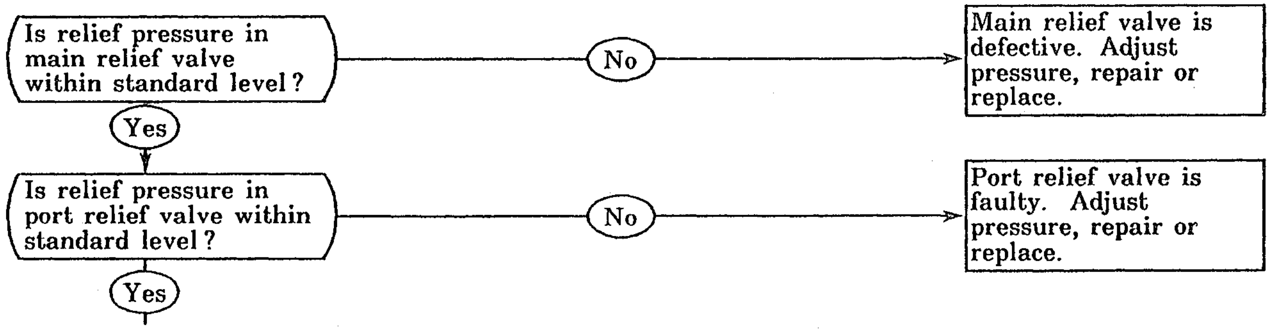

Is speed low only in composite operation?
Yes
Normal
No
Are LH/RH travel speeds within standard levels?
No
Are both LH/RH travel speeds low?
Yes
Hydraulic pump is faulty. Disassemble and repair.
No
Does the symptom change when the righthand and lefthand travel boost pressure relief valves are exchanged?
Yes
Travel boost pressure relief valve is faulty. Disassemble and repair or replace.
No
Is engine revolution within standard level?
No
Adjust engine revolution.
Yes
Are the oil streams combined normally at boom hoisting and arm operation?
No
Are control cable and link system normal?
No
Control cable and link system are faulty. Disassemble and repair or replace.
Yes
Does the control valve spool move lightly by hand?
No
Control valve spool is stuck. Disassemble and repair.
Yes
Is the return spring normal?
No
Return spring is faulty. Replace.
Yes
Are other attachment speeds within standard levels?
No
Does the symptom change when the righthand and lefthand main relief valves are exchanged?
Yes
Main relief valve is faulty. Disassemble and repair or replace.

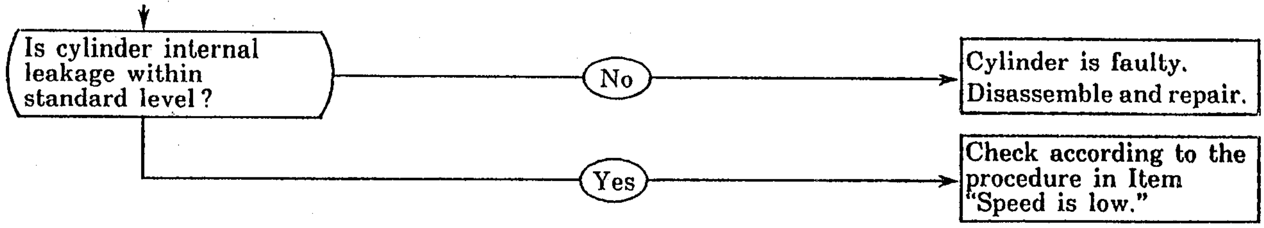

Yes
Does the symptom change when port relief valve is replaced with other valve?
Yes
Port relief valve is faulty. Disassemble and repair or replace.
No
Cylinder is faulty. Disassemble and repair.

(3) Boom, arm or bucket cylinder extends or contracts itself and attachment falls.

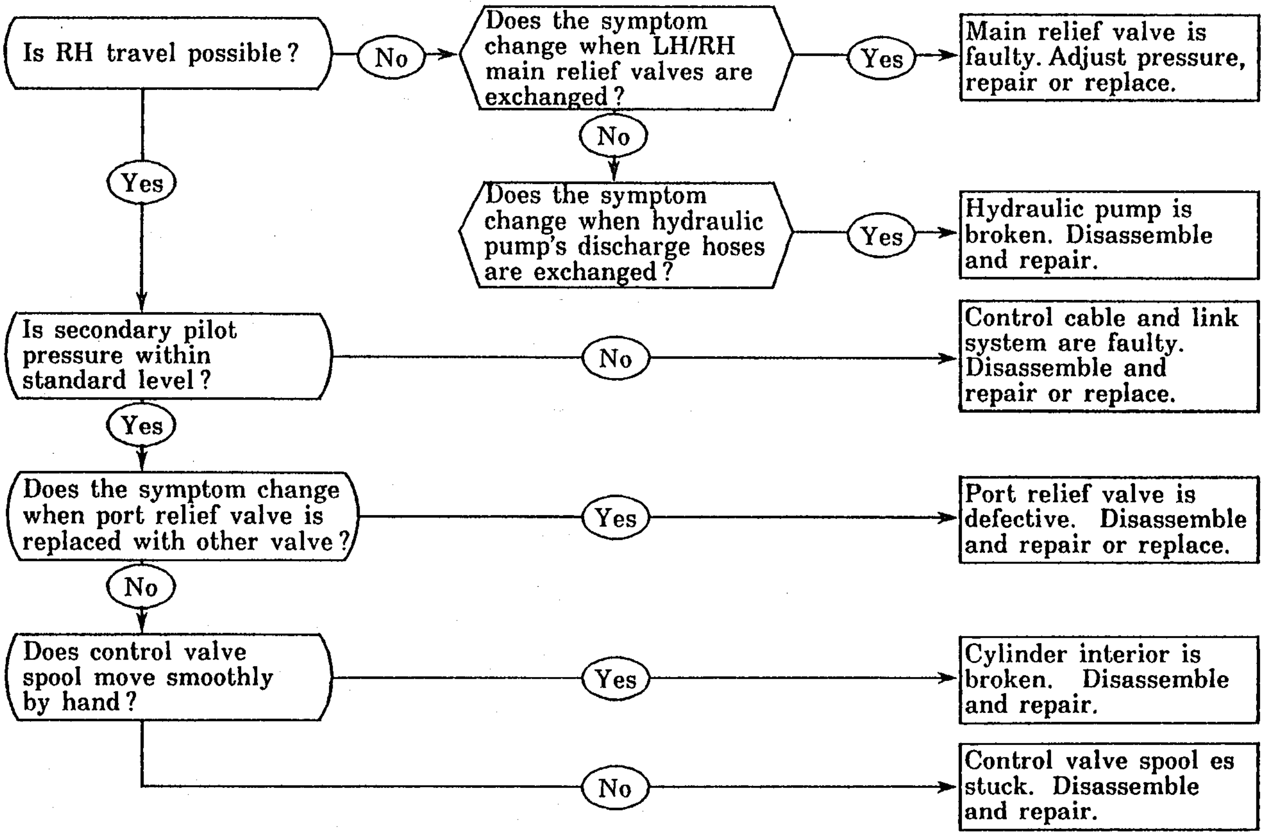

Is genuine hydraulic oil or equivalent being used?
No
Replace with genuine hydraulic oil or equivalent.
Yes
Is not hydraulic oil temperature high?
Abnormally high.
Locate the cause of hydraulic oil temperature rise and lower it to proper level.
Normal
Does the symptom change when port relief valve is replaced with normal valve?
Yes
Port relief valve is faulty. Disassemble and repair or replace.
No
Is control valve return spring normal?
No
Control valve's return spring is faulty. Disassemble and replace.
Yes
Is cylinder internal leakage within standard level?
No
Cylinder is faulty. Disassemble and repair.
Yes
Yes
Disassemble and inspect check valve in hydraulic circuit and check for any fault.
OK
Pressure tightness between control valve casing and spool is poor. Disassemble and repair.
Abnormal
Contact surface between poppet and seat is poor. Disassemble and repair.

(4) Boom, arm or bucket power is weak.

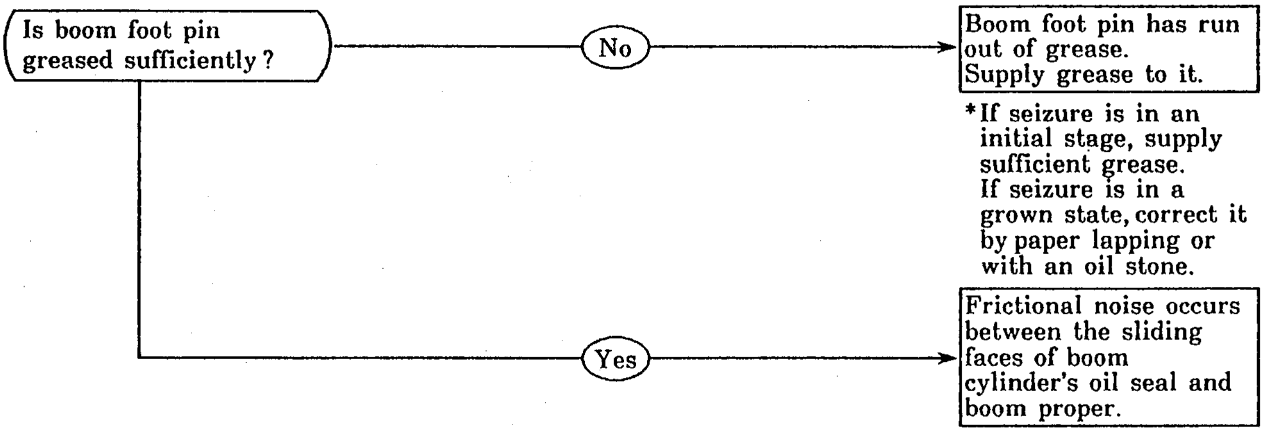

Is relief pressure in main relief valve within standard level?
No
Main relief valve is defective. Adjust pressure, repair or replace.
Yes
Is relief pressure in port relief valve within standard level?
No
Port relief valve is faulty. Adjust pressure, repair or replace.
Yes


Is cylinder internal leakage within standard level?
No
Cylinder is faulty. Disassemble and repair.
Yes
Check according to the procedure in Item "Speed is low."

(5) Only bucket operation is totally impossible.


Is RH travel possible?
No
Does the symptom change when LH/RH main relief valves are exchanged?
Yes
Main relief valve is faulty. Adjust pressure, repair or replace.
No
Does the symptom change when hydraulic pump's discharge hoses are exchanged?
Yes
Hydraulic pump is broken. Disassemble and repair.
Yes
Is secondary pilot pressure within standard level?
No
Control cable and link system are faulty. Disassemble and repair or replace.
Yes
Does the symptom change when port relief valve is replaced with other valve?
Yes
Port relief valve is defective. Disassemble and repair or replace.
No
Does control valve spool move smoothly by hand?
Yes
Cylinder interior is broken. Disassemble and repair.
No
Control valve spool es stuck. Disassemble and repair.

(6) Boom makes a squeaking noise when boom is operated.


Is boom foot pin greased sufficiently?
No
Boom foot pin has run out of grease. Supply grease to it.
Yes
Frictional noise occurs between the sliding faces of boom cylinder's oil seal and boom proper.

*If seizure is in an initial stage, supply sufficient grease. If seizure is in a grown state, correct it by paper lapping or with an oil stone.

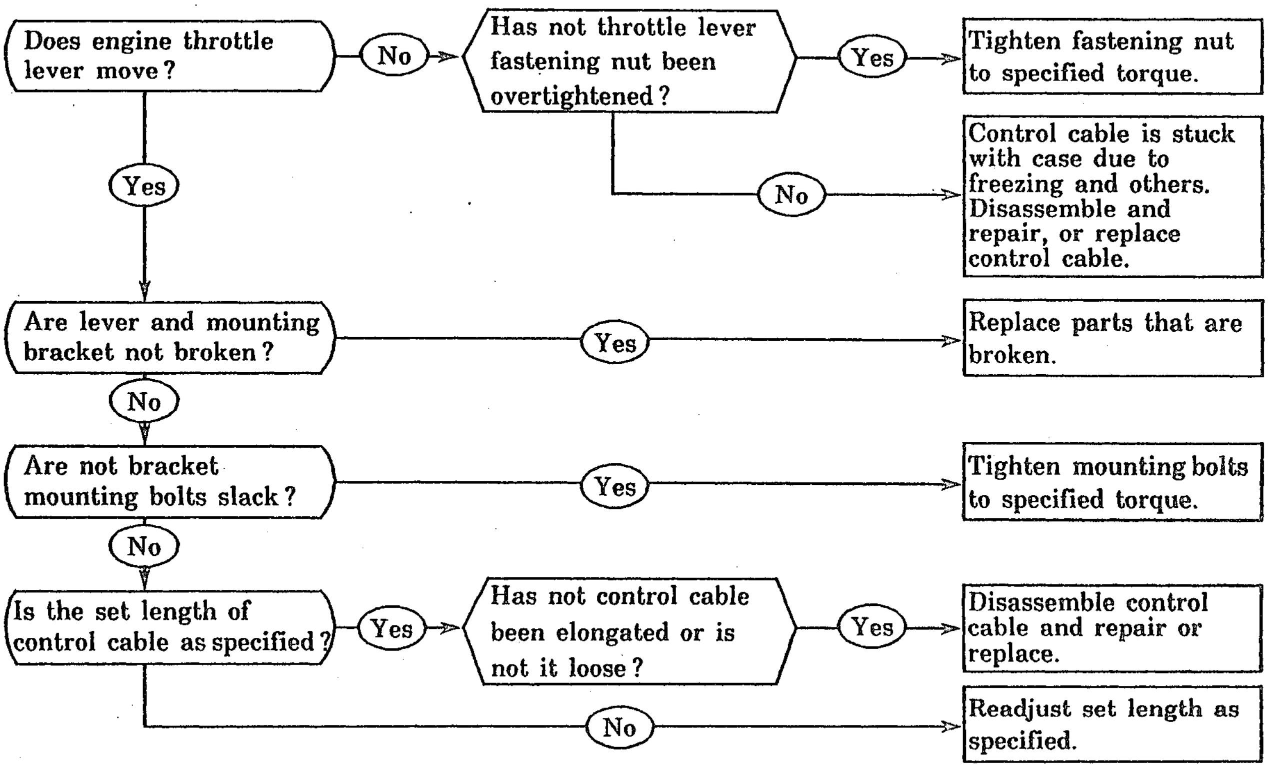
*Frictional noise will disappear if they are kept used.

(7) If boom, arm and bucket are operated independently and slowly against their motions, they begin to move in reverse direction and then move in original direction.

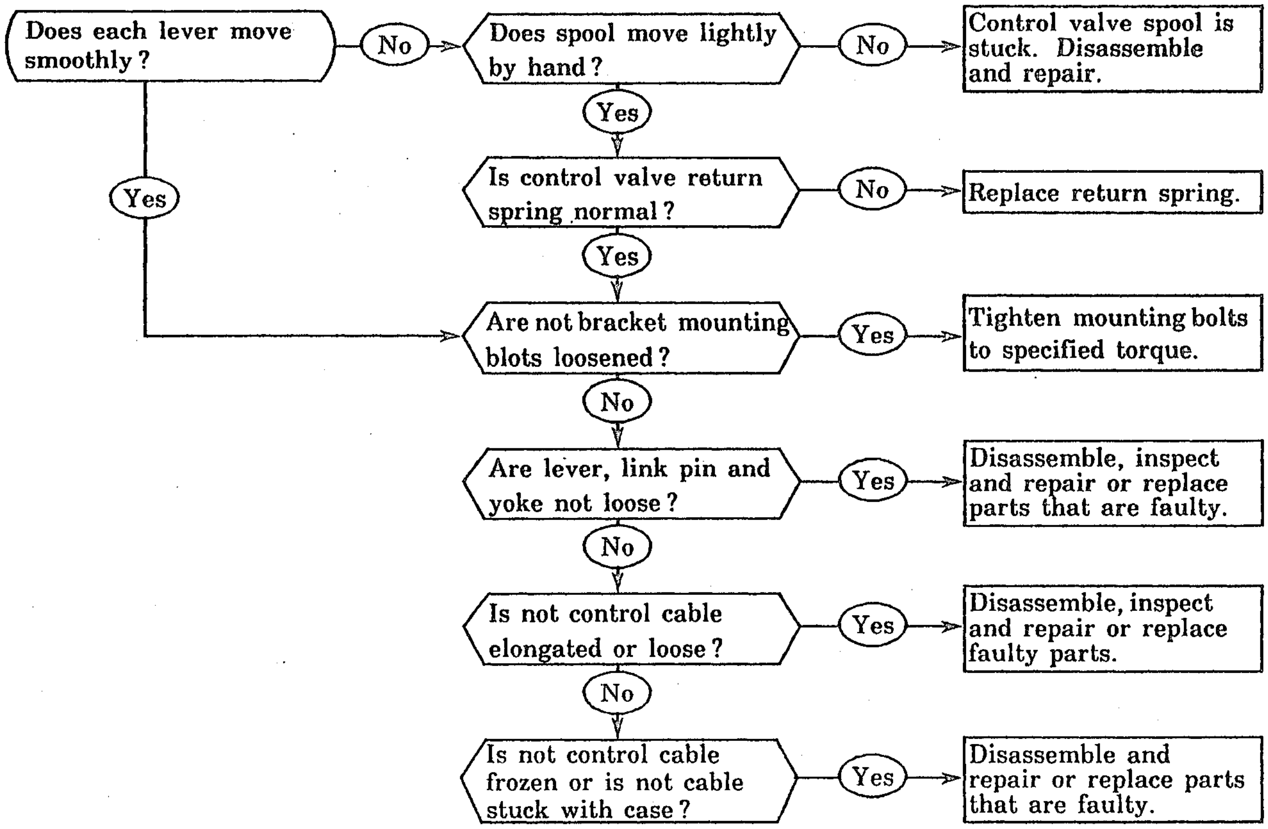
Dirt is included in load check valve in each control valve, or the contact surface between poppet and seat is faulty. Disassemble and repair.

7. CONTROL SYSTEM

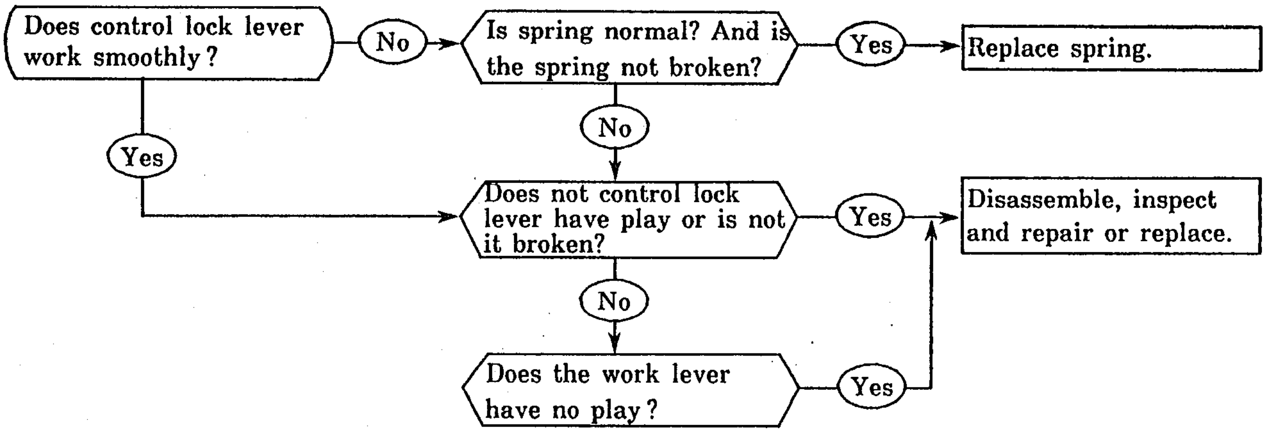
(1) The machine can not be controlled even if the engine throttle lever is operated.


Does engine throttle lever move?
No
Has not throttle lever fastening nut been overtightened?
Yes
Tighten fastening nut to specified torque.
No
Control cable is stuck with case due to freezing and others. Disassemble and repair, or replace control cable.
Yes
Are lever and mounting bracket not broken?
Yes
Replace parts that are broken.
No
Are not bracket mounting bolts slack?
Yes
Tighten mounting bolts to specified torque.
No
Is the set length of control cable as specified?
Yes
Has not control cable been elongated or is not it loose?
Yes
Disassemble control cable and repair or replace.
No
Readjust set length as specified.

(2) Spool does not switch over when travel lever is operated.


Does each lever move smoothly?
No
Does spool move lightly by hand?
No
Control valve spool is stuck. Disassemble and repair.
Yes
Is control valve return spring normal?
No
Replace return spring.
Yes
Yes
Are not bracket mounting blots loosened?
Yes
Tighten mounting bolts to specified torque.
No
Are lever, link pin and yoke not loose?
Yes
Disassemble, inspect and repair or replace parts that are faulty.
No
Is not control cable elongated or loose?
Yes
Disassemble, inspect and repair or replace faulty parts.
No
Is not control cable frozen or is not cable stuck with case?
Yes
Disassemble and repair or replace parts that are faulty.

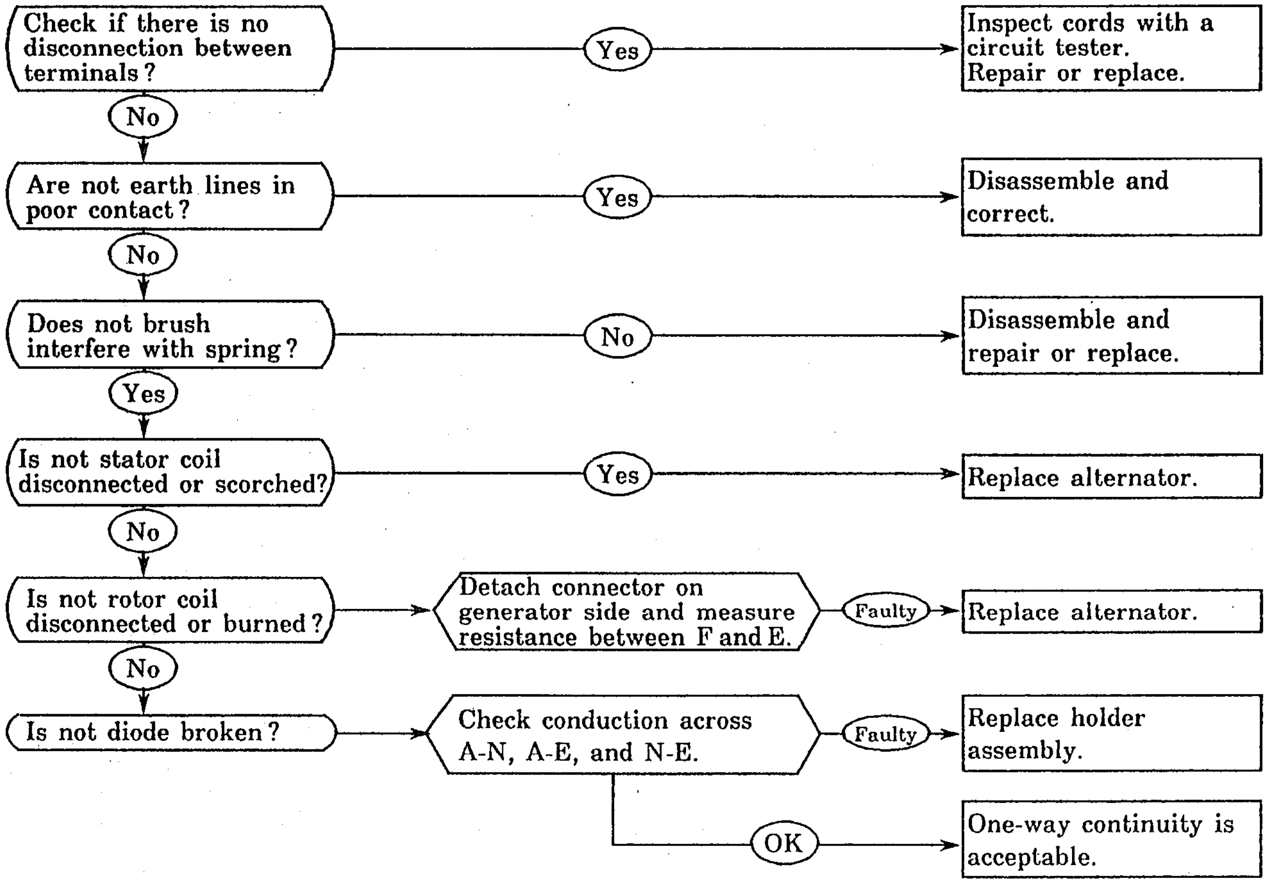
(3) Locking function does not work even when control look lever is operated.


Does control lock lever work smoothly?
No
Is spring normal? And is the spring not broken?
Yes
Replace spring.
No
Yes
Does not control lock lever have play or is not it broken?
Yes
Disassemble, inspect and repair or replace.
No
Does the work lever have no play?
Yes

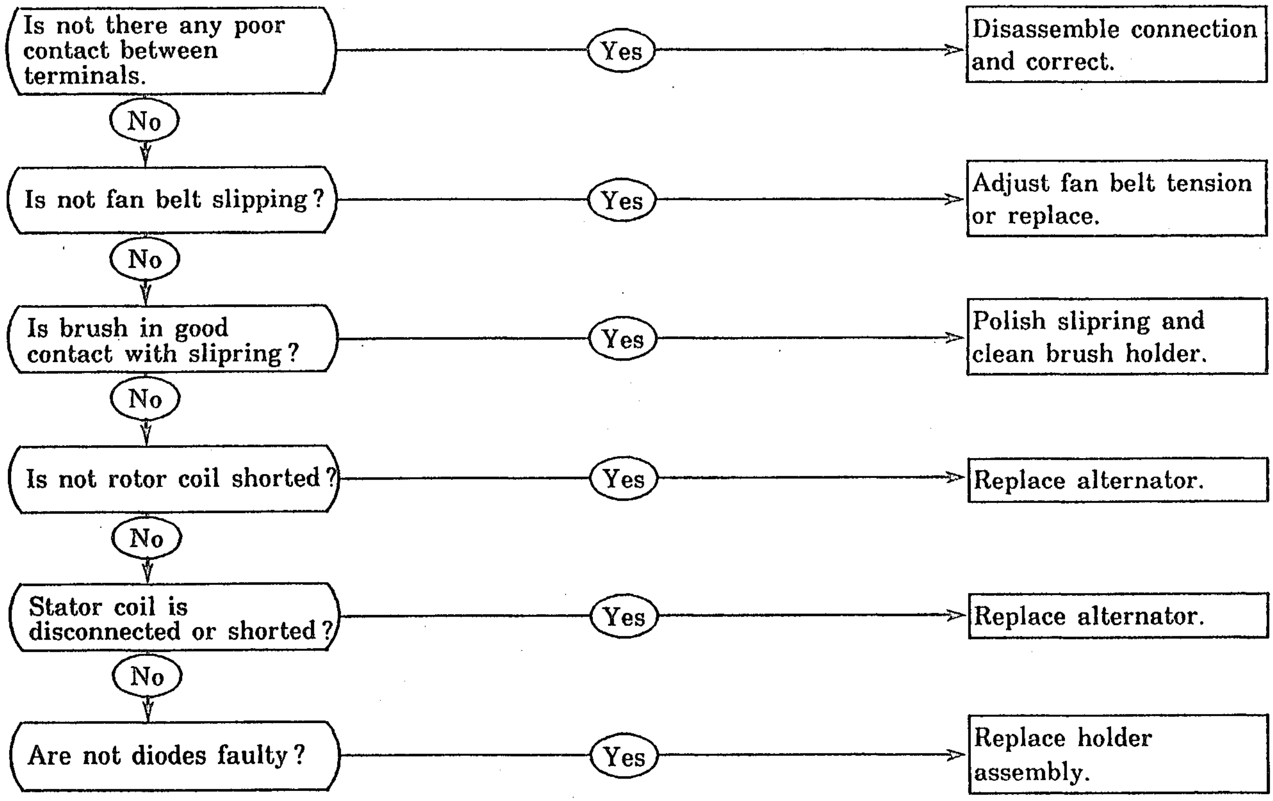
8. ELECTRICAL SYSTEM

A. ALTERNATOR SECTION

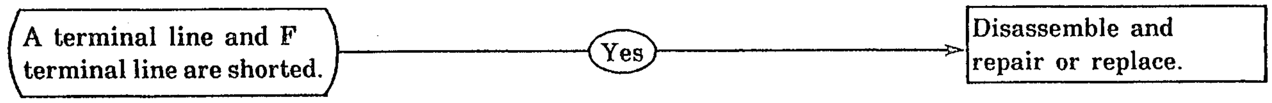
(1) Alternator does not charge at all.


Check if there is no disconnection between terminals?
Yes
Inspect cords with a circuit tester. Repair or replace.
No
Are not earth lines in poor contact?
Yes
Disassemble and correct.
No
Does not brush interfere with spring?
No
Disassemble and repair or replace.
Yes
Is not stator coil disconnected or scorched?
Yes
Replace alternator.
No
Is not rotor coil disconnected or burned?
Detach connector on generator side and measure resistance between F and E.
Faulty
Replace alternator.
No
Is not diode broken?
Check conduction across A-N, A-E, and N-E.
Faulty
Replace holder assembly.
OK
One-way continuity is acceptable.

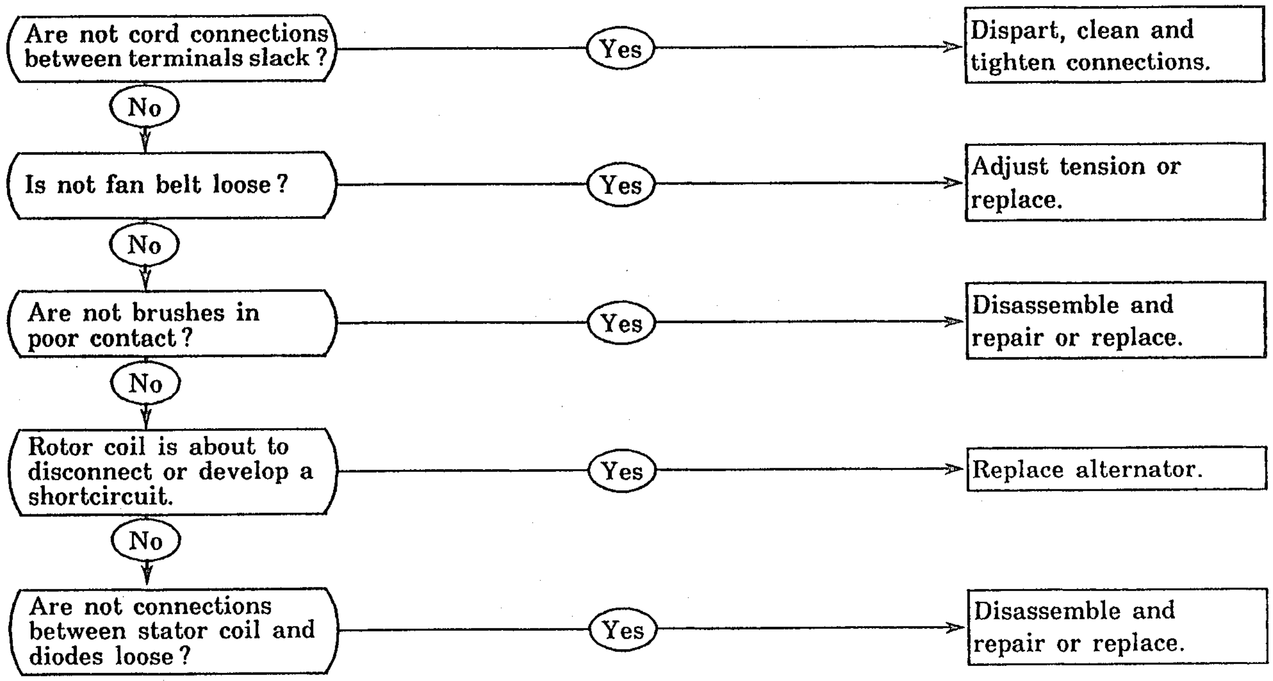
(2) Charge is not sufficient.


Is not there any poor contact between terminals.
Yes
Disassemble connection and correct.
No
Is not fan belt slipping?
Yes
Adjust fan belt tension or replace.
No
Is brush in good contact with slipring?
Yes
Polish slipring and clean brush holder.
No
Is not rotor coil shorted?
Yes
Replace alternator.
No
Stator coil is disconnected or shorted?
Yes
Replace alternator.
No
Are not diodes faulty?
Yes
Replace holder assembly.

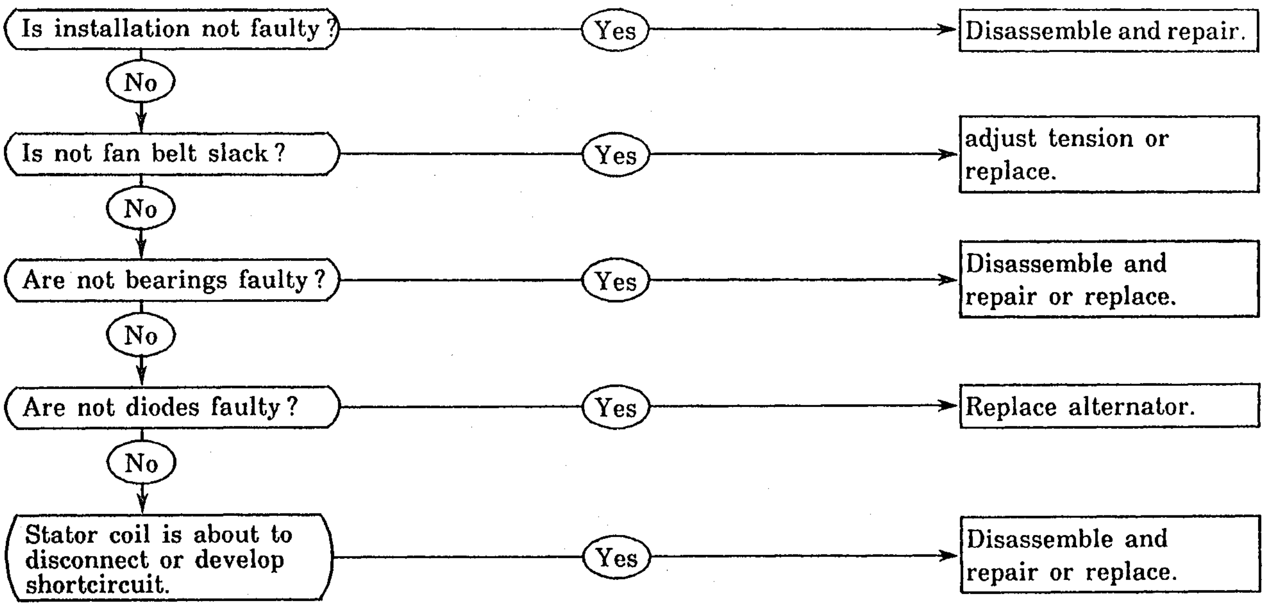
(3) Alternator overcharges.


A terminal line and F terminal line are shorted.
Yes
Disassemble and repair or replace.

(4) Charge current is unstable.

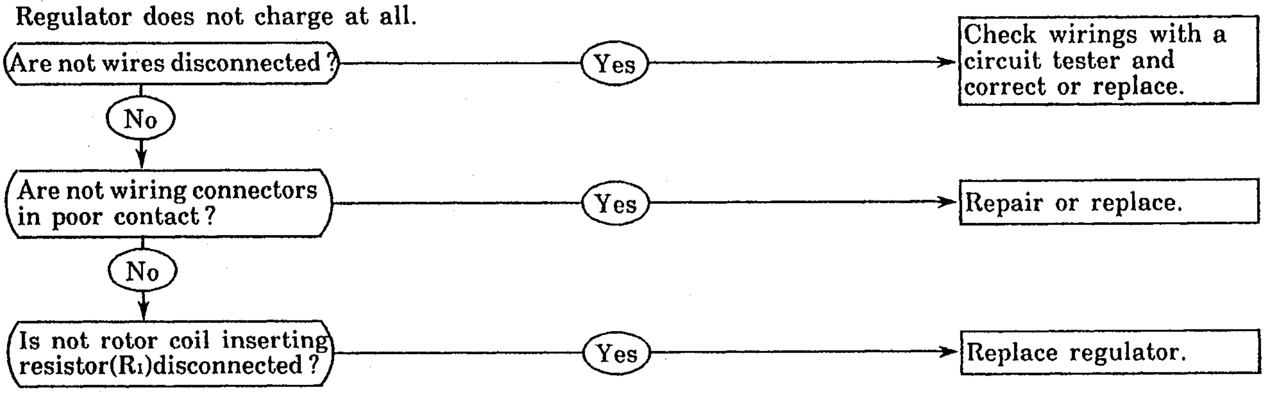

Are not cord connections between terminals slack?
Yes
Dispart, clean and tighten connections.
No
Is not fan belt loose?
Yes
Adjust tension or replace.
No
Are not brushes in poor contact?
Yes
Disassemble and repair or replace.
No
Rotor coil is about to disconnect or develop a shortcircuit.
Yes
Replace alternator.
No
Are not connections between stator coil and diodes loose?
Yes
Disassemble and repair or replace.

(5) Unusual noise comes out.

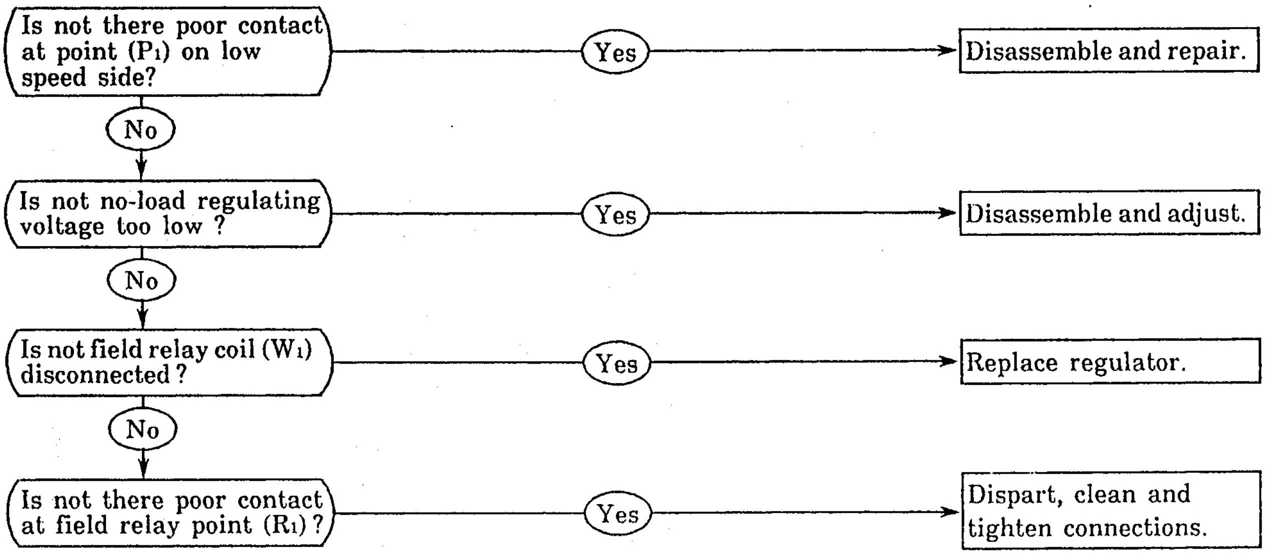

Is installation not faulty ?
Yes
Disassemble and repair.
No
Is not fan belt slack ?
Yes
adjust tension or replace.
No
Are not bearings faulty ?
Yes
Disassemble and repair or replace.
No
Are not diodes faulty ?
Yes
Replace alternator.
No
Stator coil is about to disconnect or develop shortcircuit.
Yes
Disassemble and repair or replace.

B. REGULATOR SECTION

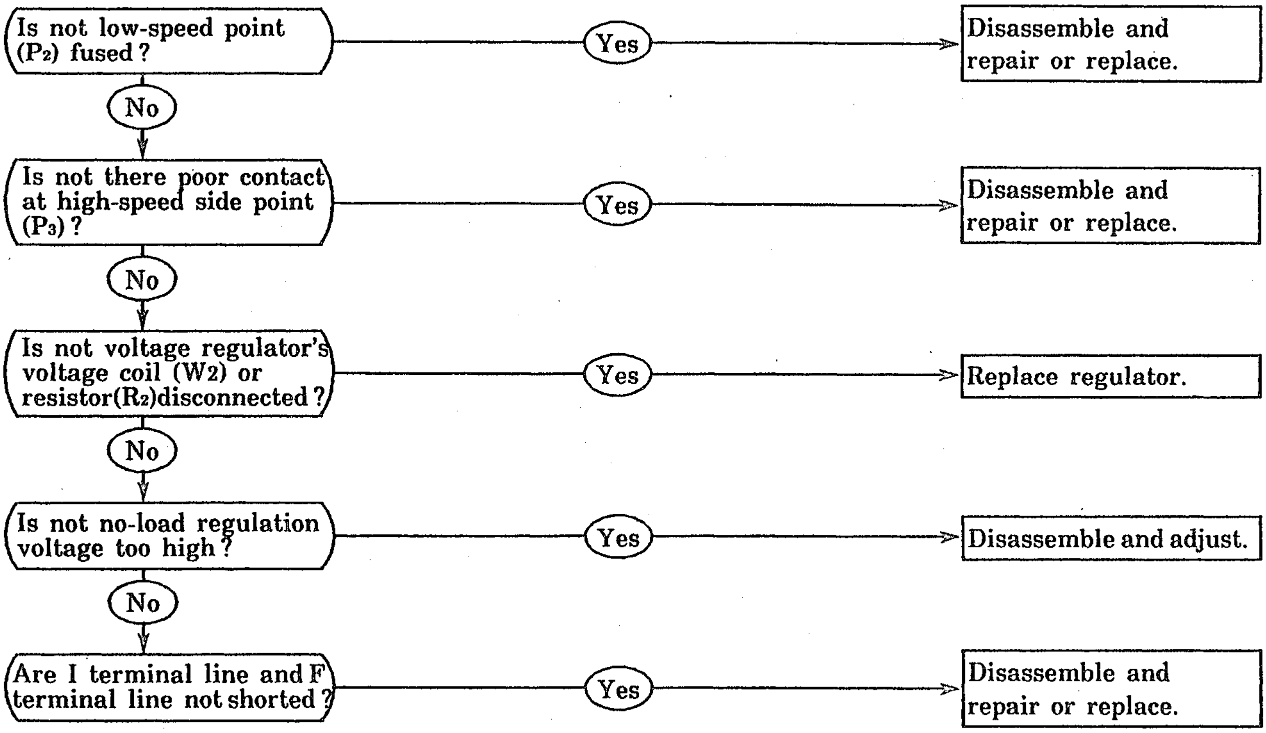
(1) Regulator does not charge at all.


Are not wires disconnected ?
Yes
Check wirings with a circuit tester and correct or replace.
No
Are not wiring connectors in poor contact ?
Yes
Repair or replace.
No
Is not rotor coil inserting resistor(R1)disconnected ?
Yes
Replace regulator.

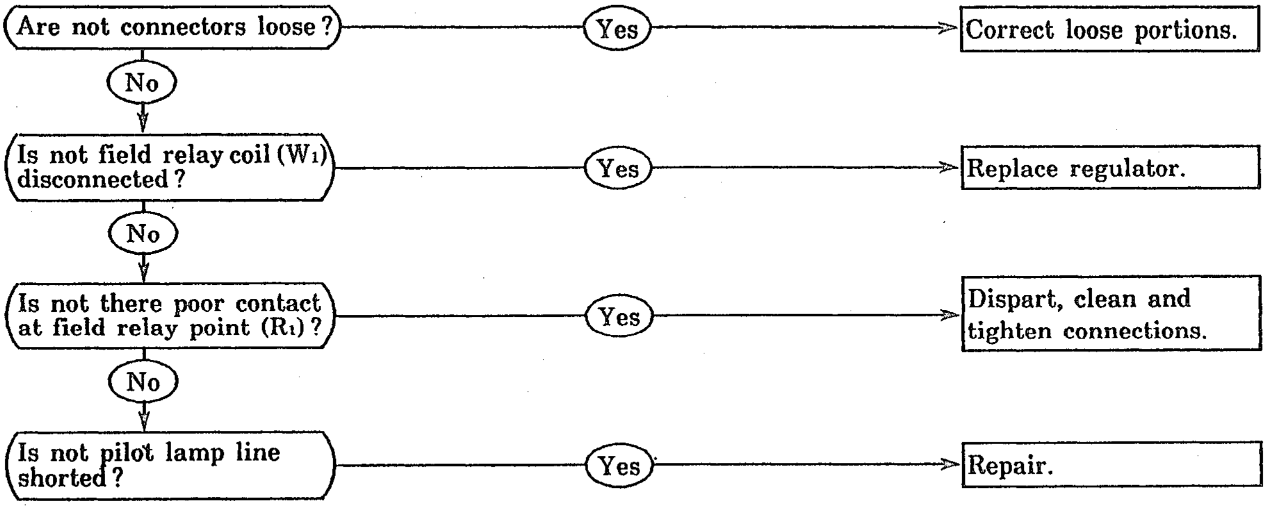
(2) Regulator undercharges.


Is not there poor contact at point (P1) on low speed side?
Yes
Disassemble and repair.
No
Is not no-load regulating voltage too low ?
Yes
Disassemble and adjust.
No
Is not field relay coil (W1) disconnected ?
Yes
Replace regulator.
No
Is not there poor contact at field relay point (R1) ?
Yes
Dispart, clean and tighten connections.

(3) Regulator overcharges.

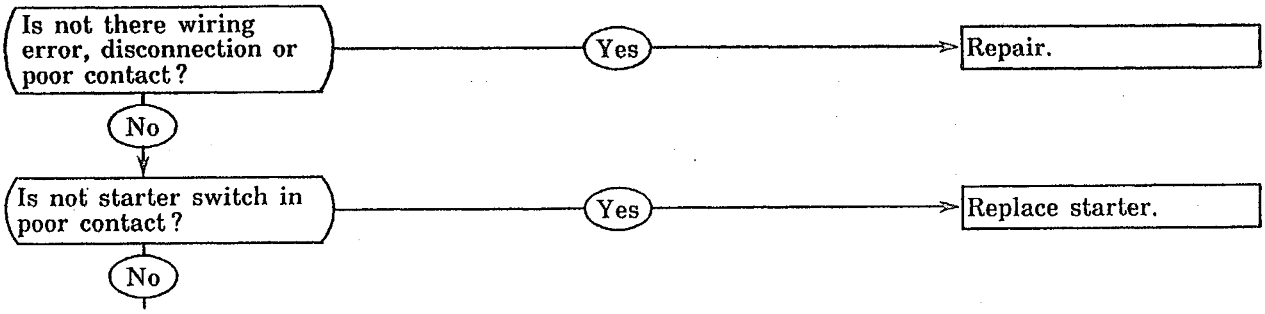

Is not low-speed point (P2) fused?
Yes
Disassemble and repair or replace.
No
Is not there poor contact at high-speed side point (P3)?
Yes
Disassemble and repair or replace.
No
Is not voltage regulator's voltage coil (W2) or resistor(R2)disconnected?
Yes
Replace regulator.
No
Is not no-load regulation voltage too high?
Yes
Disassemble and adjust.
No
Are I terminal line and F terminal line not shorted?
Yes
Disassemble and repair or replace.

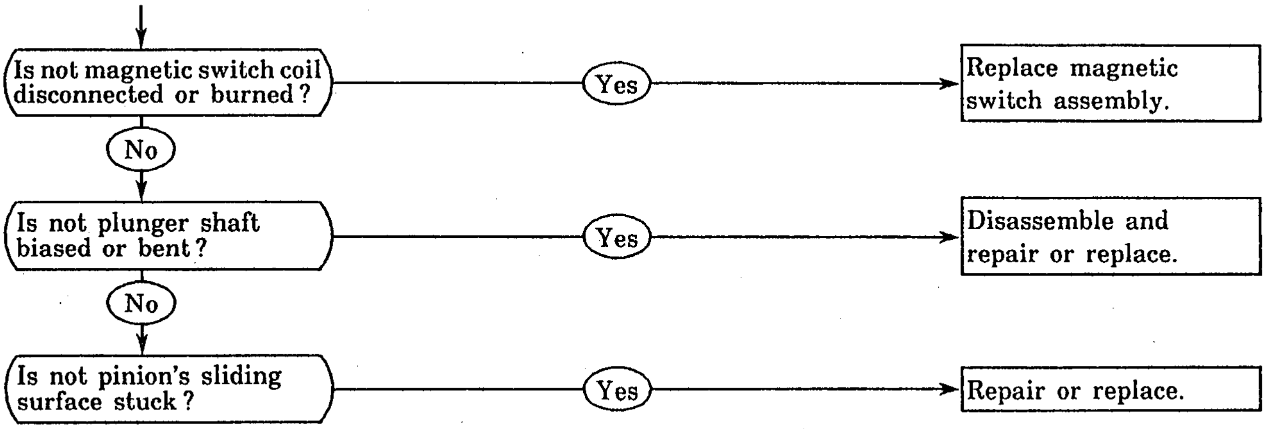
(4) Pilot lamp lights.


Are not connectors loose?
Yes
Correct loose portions.
No
Is not field relay coil (W1) disconnected?
Yes
Replace regulator.
No
Is not there poor contact at field relay point (R1)?
Yes
Dispart, clean and tighten connections.
No
Is not pilot lamp line shorted?
Yes
Repair.

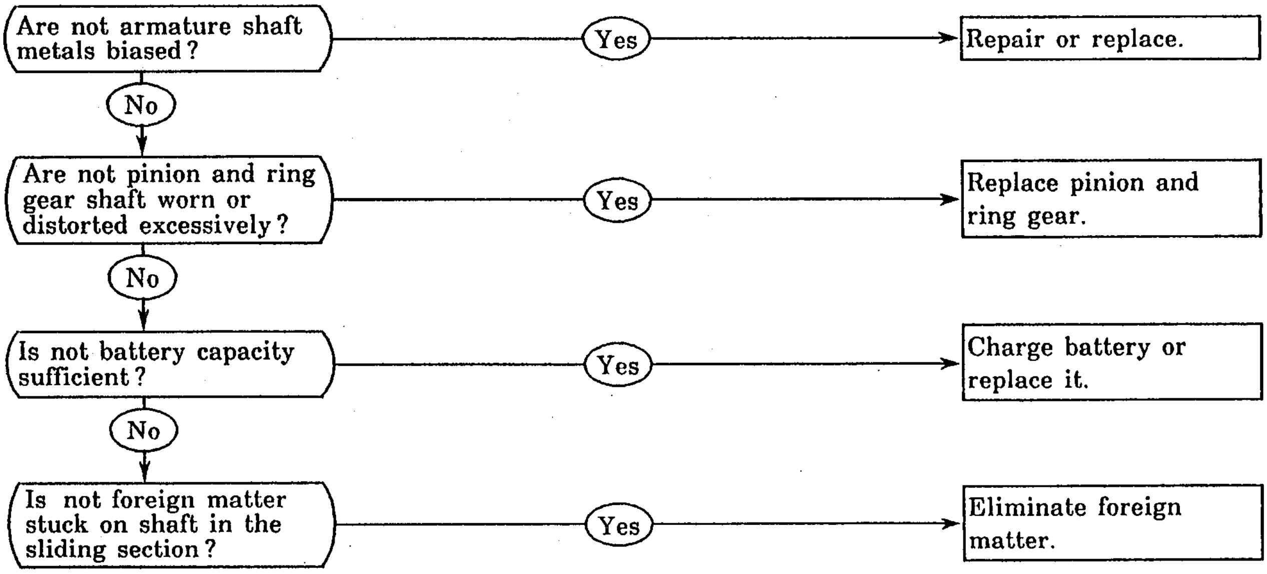
C. STARTER

(1) Magnetic switch does not work even when starter switch is turned on.

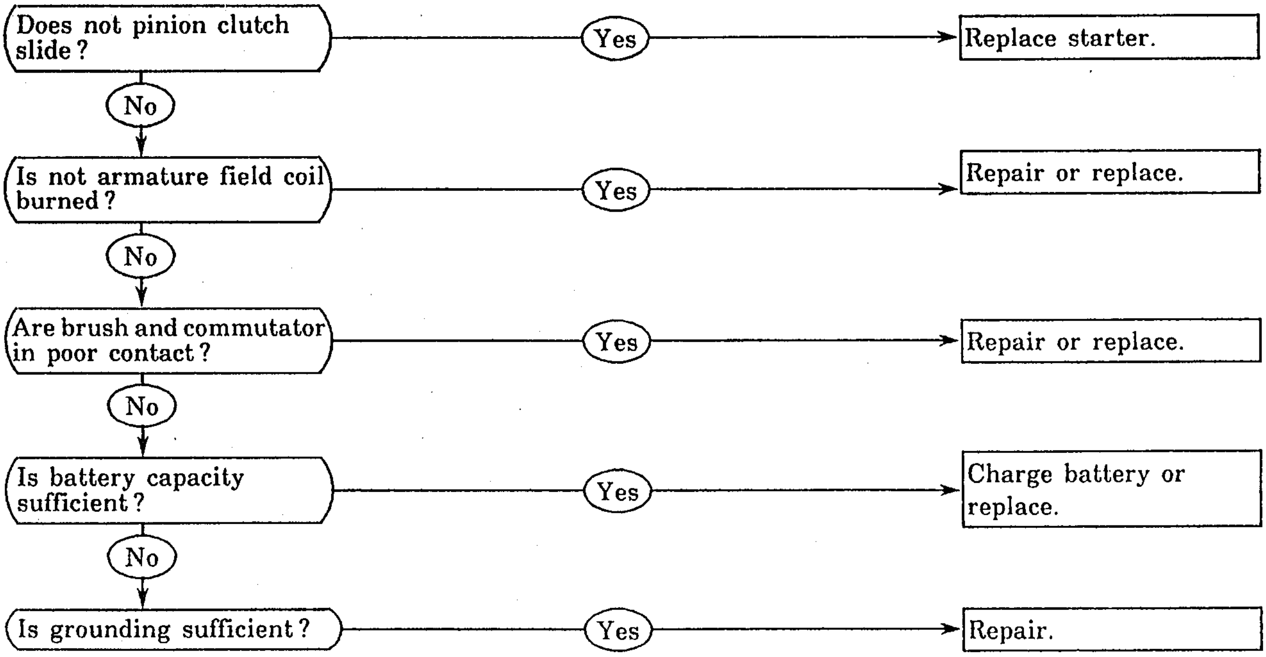

Is not there wiring error, disconnection or poor contact?
Yes
Repair.
No
Is not starter switch in poor contact?
Yes
Replace starter.
No


Is not magnetic switch coil disconnected or burned?
Yes
Replace magnetic switch assembly.
No
Is not plunger shaft biased or bent?
Yes
Disassemble and repair or replace.
No
Is not pinion's sliding surface stuck?
Yes
Repair or replace.

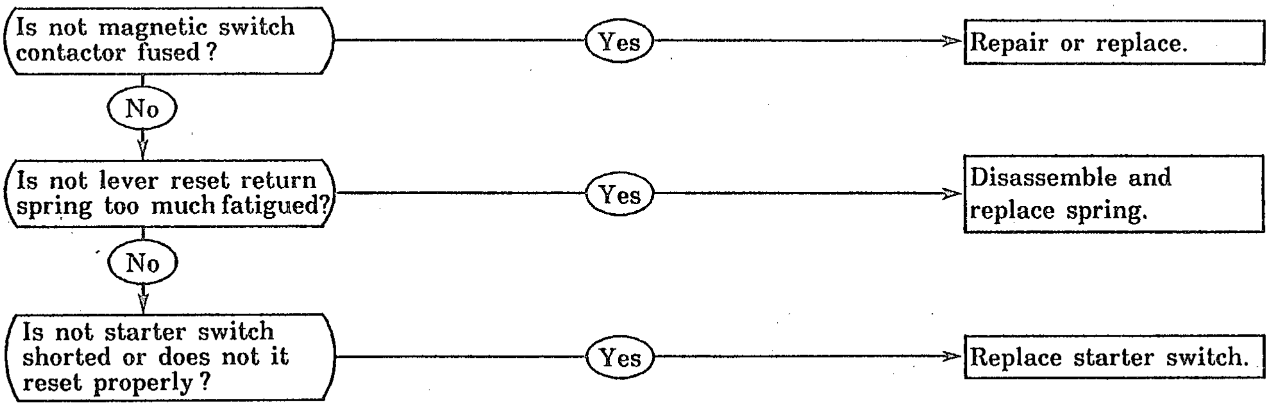
(2) Pinion gear does not completely mesh with ring gear.


Are not armature shaft metals biased?
Yes
Repair or replace.
No
Are not pinion and ring gear shaft worn or distorted excessively?
Yes
Replace pinion and ring gear.
No
Is not battery capacity sufficient?
Yes
Charge battery or replace it.
No
Is not foreign matter stuck on shaft in the sliding section?
Yes
Eliminate foreign matter.

(3) Pinion meshes with ring gear but engine does not run.

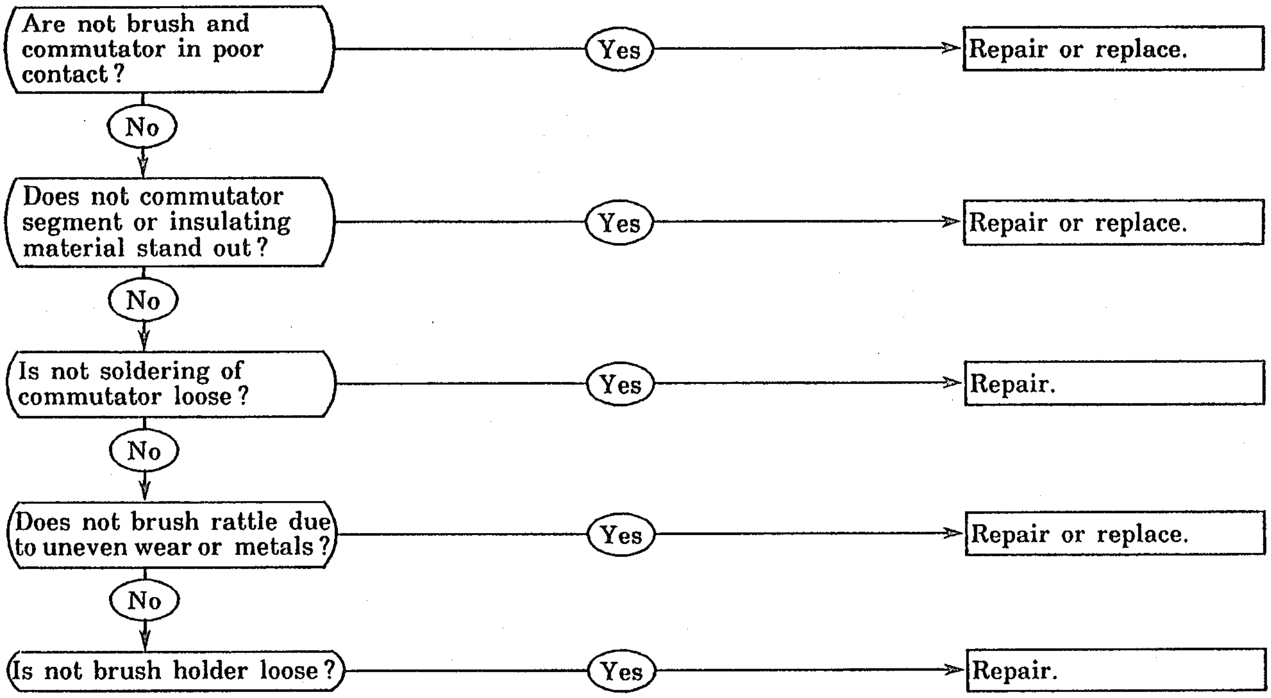

Does not pinion clutch slide?
Yes
Replace starter.
No
Is not armature field coil burned?
Yes
Repair or replace.
No
Are brush and commutator in poor contact?
Yes
Repair or replace.
No
Is battery capacity sufficient?
Yes
Charge battery or replace.
No
Is grounding sufficient?
Yes
Repair.

(4) Starter does not stop running even if starter switch is turned off.



Is not magnetic switch contactor fused?
Yes
Repair or replace.
No
Is not lever reset return spring too much fatigued?
Yes
Disassemble and replace spring.
No
Is not starter switch shorted or does not it reset properly?
Yes
Replace starter switch.

(5) Brush sparks extremely.



Are not brush and commutator in poor contact?
Yes
Repair or replace.
No
Does not commutator segment or insulating material stand out?
Yes
Repair or replace.
No
Is not soldering of commutator loose?
Yes
Repair.
No
Does not brush rattle due to uneven wear or metals?
Yes
Repair or replace.
No
Is not brush holder loose?
Yes
Repair.

9. MECHATRONICS SYSTEM

(See the Maintenance Standards and Test Procedures.)

(1) Are not mechatronics system error?.

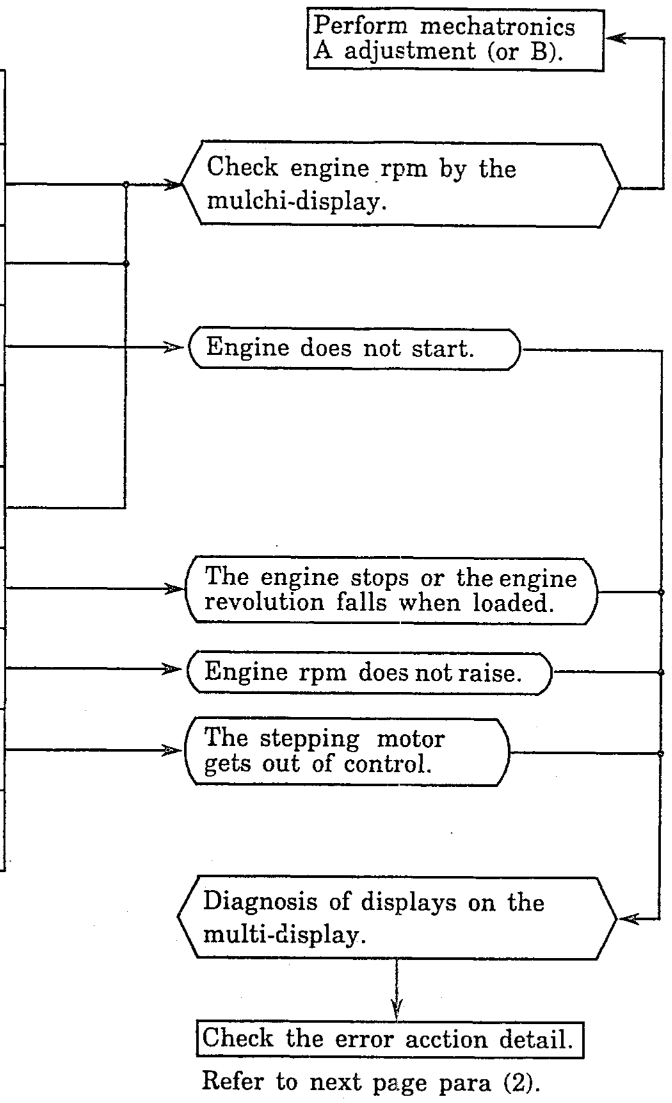
(To shoot trouble place and to check the user claim and to be not error.)

Diagnosis by checking the flashing of the auto accel lamp

Code	Contents	Flashing pattern (▨ Light on □ Light off)	Checking the present condition
0	Engine stops or engine revolution is less than 420 rpm.	▨▨▨□□□□□□□	Electric wiring to rotary sensor.
1	Data in ROM is incorrect or not adjusted yet.	▨□▨▨▨□□□□□	Perform adjustments A and B.
2	Starting point of stepping motor is under indexing or indexing is impossible	▨□▨□▨▨▨□□□	Check stepping motor and limit switch and confirm electric wiring.
3	Reverse rotation of engine was determined. (SK60, SK100, SK120 only)	▨□▨□▨□▨▨▨□	Check engine oil pressure switch and engine water temperature switch. Also check electric wiring.
4	Mechatronical adjustment failed.	▨□▨□▨□▨□▨□	Perform adjustments A (and B).
5	Improper current is running to solenoid valve (Power shift) (Loading mode)	▨▨▨□▨□▨□▨□	Check electric wiring to solenoid valve.
6	Improper current is running to stepping motor. (Less than 1A and more than 2A)	▨▨▨□▨□▨□□□	Check electric wiring to stepping motor.
7	Stepping motor runs abnormally.	▨▨▨□▨□□□□□	Check the mounted condition of stepping motor, link rod. etc.
	Is normal condition.	▨▨▨▨▨▨▨▨▨▨	

0.32sec.

5.12sec.


Perform mechatronics A adjustment (or B).
Check engine rpm by the mulchi-display.
Engine does not start.
The engine stops or the engine revolution falls when loaded.
Engine rpm does not raise.
The stepping motor gets out of control.
Diagnosis of displays on the multi-display.
Check the error acction detail.
Refer to next page para (2).

A. Diagnosis by the flashing of Auto Accel Lamp

① After starting the engine, keep the buzzer stop switch pressed. 6-10 seconds later the contents of fault is indicated in a flashing pattern.

② This flashing pattern is indicated repeatedly.

③ The indication goes away the moment the hand is let free from the buzzer stop switch.

④ The function is normal if the display lights continuously. Note, however, that in case more than one fault occurs at the same time, they are indicated in sequence.

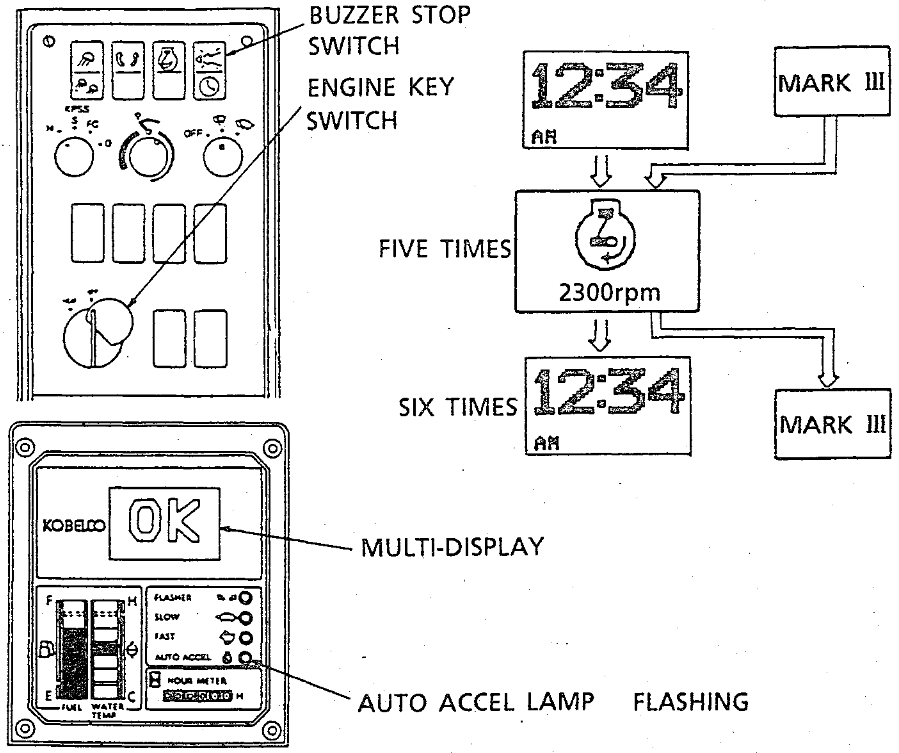
B. Diagnosis of Engine Revolution

① After starting the engine, depress the buzzer stop switch five times; the revolution is displayed.

② If the buzzer stop switch is pressed one more time, the display returns to time display.

③ One more pressing brings back revolution display.

④ Thereafter, display changes over each time the buzzer stop switch is depressed.


BUZZER STOP SWITCH
ENGINE KEY SWITCH
12:34
AM
MARK III
FIVE TIMES
2300rpm
SIX TIMES
12:34
AM
MARK III
KOBELCO
OK
MULTI-DISPLAY
FLASHER
SLOW
FAST
AUTO ACCEL
HOUR METER
FUEL
WATER TEMP
AUTO ACCEL LAMP FLASHING

C. Diagnosis of Displays on the Multi-Display

① Turn the key switch from OFF to ON with the buzzer stop switch depressed.

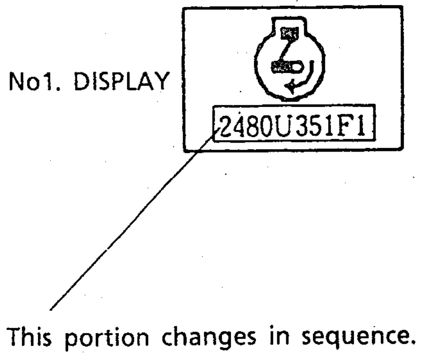
② If the buzzer stop switch is depressed five times, the operating condition of the mechatronics system is indicated on the multi-display.

③ Thereafter, the status of 24 items is indicated in sequence each time the buzzer stop switch is depressed.

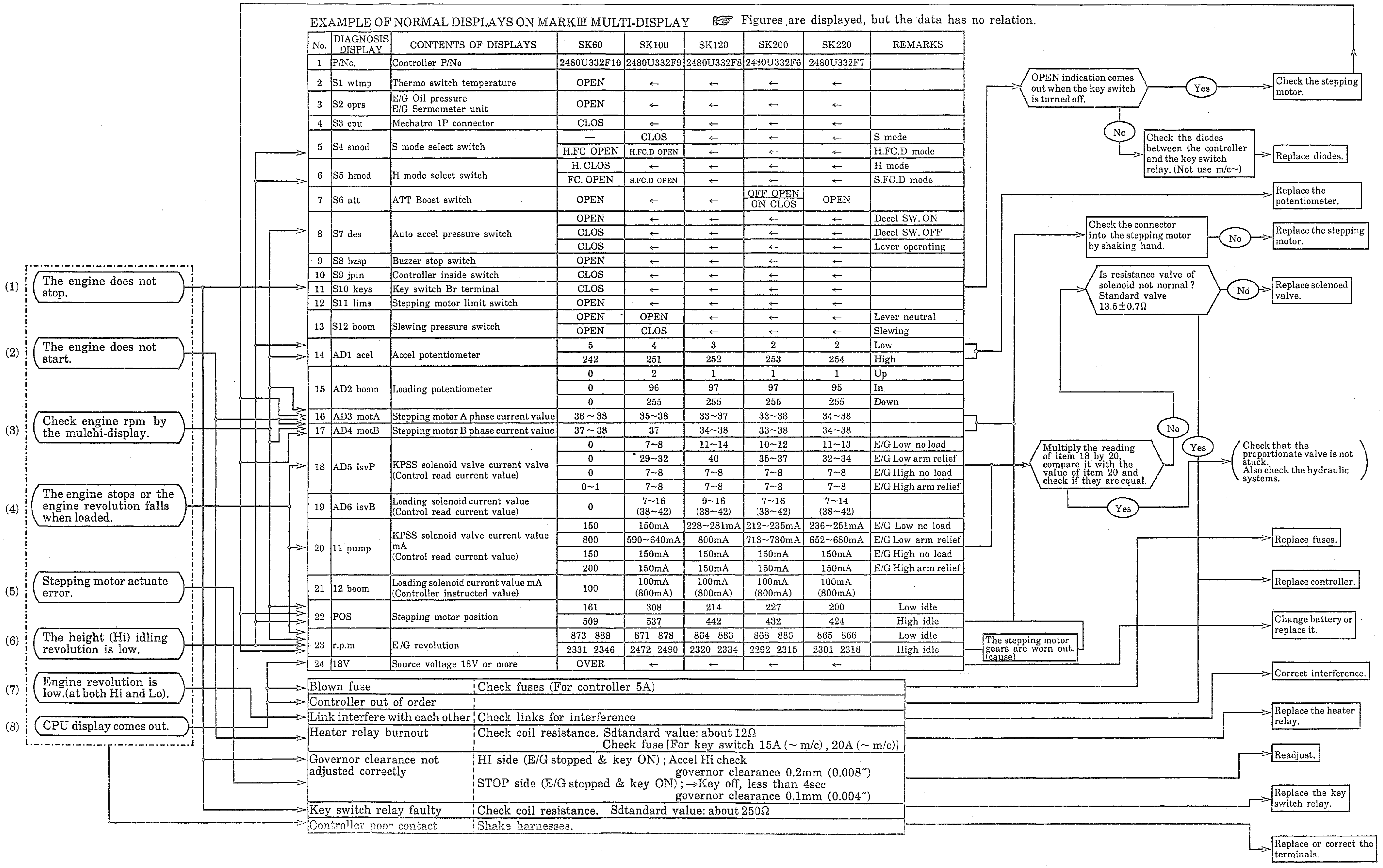
④ The No.1 item is indicated if the switch is depressed 25 times.

⑤ The display goes out if the key switch is turned OFF.

☞ Key switch must be turned OFF when the electric parts are checked, the harness connections are checked and connectors are pull out or inserted, if key switch is on controller adjustment data may be broken.


No1. DISPLAY
2480U351F1
This portion changes in sequence.

(2) Check the error acction detail


(1) The engine does not stop.
(2) The engine does not start.
(3) Check engine rpm by the mulchi-display.
(4) The engine stops or the engine revolution falls when loaded.
(5) Stepping motor actuate error.
(6) The height (Hi) idling revolution is low.
(7) Engine revolution is low.(at both Hi and Lo).
(8) CPU display comes out.
OPEN indication comes out when the key switch is turned off.
Yes
No
Check the stepping motor.
Check the diodes between the controller and the key switch relay. (Not use m/c~)
Replace diodes.
Replace the potentiometer.
Check the connector into the stepping motor by shaking hand.
No
Replace the stepping motor.
Is resistance valve of solenoid not normal ? Standard valve 13.5±0.7Ω
No
Replace solenoed valve.
No
Yes
Multiply the reading of item 18 by 20, compare it with the value of item 20 and check if they are cqual.
Yes
Check that the proportionate valve is not stuck. Also check the hydraulic systems.
The stepping motor gears are worn out. (cause)
Replace fuses.
Replace controller.
Change battery or replace it.
Correct interference.
Replace the heater relay.
Readjust.
Replace the key switch relay.
Replace or correct the terminals.

EXAMPLE OF NORMAL DISPLAYS ON MARKIII MULTI-DISPLAY ☞ Figures are displayed, but the data has no relation.

No.	DIAGNOSIS DISPLAY	CONTENTS OF DISPLAYS	SK60	SK100	SK120	SK200	SK220	REMARKS
1	P/No.	Controller P/No	2480U332F10	2480U332F9	2480U332F8	2480U332F6	2480U332F7	
2	S1 wtmp	Thermo switch temperature	OPEN	←	←	←	←	
3	S2 oprs	E/G Oil pressure E/G Sermometer unit	OPEN	←	←	←	←	
4	S3 cpu	Mechatro 1P connector	CLOS	←	←	←	←	
5	S4 smod	S mode select switch	—	CLOS	←	←	←	S mode
			H.FC OPEN	H.FC.D OPEN	←	←	←	H.FC.D mode
6	S5 hmod	H mode select switch	H. CLOS	←	←	←	←	H mode
			FC. OPEN	S.FC.D OPEN	←	←	←	S.FC.D mode
7	S6 att	ATT Boost switch	OPEN	←	←	OFF OPEN ON CLOS	OPEN	
8	S7 des	Auto accel pressure switch	OPEN	←	←	←	←	Decel SW. ON
			CLOS	←	←	←	←	Decel SW. OFF
			CLOS	←	←	←	←	Lever operating
9	S8 bzsp	Buzzer stop switch	OPEN	←	←	←	←	
10	S9 jpin	Controller inside switch	CLOS	←	←	←	←	
11	S10 keys	Key switch Br terminal	CLOS	←	←	←	←	
12	S11 lims	Stepping motor limit switch	OPEN	←	←	←	←	
13	S12 boom	Slewing pressure switch	OPEN	OPEN	←	←	←	Lever neutral
			OPEN	CLOS	←	←	←	Slewing
14	AD1 acel	Accel potentiometer	5	4	3	2	2	Low
			242	251	252	253	254	High
15	AD2 boom	Loading potentiometer	0	2	1	1	1	Up
			0	96	97	97	95	In
			0	255	255	255	255	Down
16	AD3 motA	Stepping motor A phase current value	36 ~ 38	35~38	33~37	33~38	34~38	
17	AD4 motB	Stepping motor B phase current value	37 ~ 38	37	34~38	33~38	34~38	
18	AD5 isvP	KPSS solenoid valve current valve (Control read current value)	0	7~8	11~14	10~12	11~13	E/G Low no load
			0	29~32	40	35~37	32~34	E/G Low arm relief
			0	7~8	7~8	7~8	7~8	E/G High no load
			0~1	7~8	7~8	7~8	7~8	E/G High arm relief
19	AD6 isvB	Loading solenoid current value (Control read current value)	0	7~16 (38~42)	9~16 (38~42)	7~16 (38~42)	7~14 (38~42)	
20	11 pump	KPSS solenoid valve current value mA (Control read current value)	150	150mA	228~281mA	212~235mA	236~251mA	E/G Low no load
			800	590~640mA	800mA	713~730mA	652~680mA	E/G Low arm relief
			150	150mA	150mA	150mA	150mA	E/G High no load
			200	150mA	150mA	150mA	150mA	E/G High arm relief
21	12 boom	Loading solenoid current value mA (Controller instructed value)	100	100mA (800mA)	100mA (800mA)	100mA (800mA)	100mA (800mA)	
22	POS	Stepping motor position	161	308	214	227	200	Low idle
			509	537	442	432	424	High idle
23	r.p.m	E/G revolution	873 888	871 878	864 883	868 886	865 866	Low idle
			2331 2346	2472 2490	2320 2334	2292 2315	2301 2318	High idle
24	18V	Source voltage 18V or more	OVER	←	←	←	←	

Blown fuse	Check fuses (For controller 5A)
Controller out of order	
Link interfere with each other	Check links for interference
Heater relay burnout	Check coil resistance. Sdtandard value: about 12Ω Check fuse [For key switch 15A (~ m/c), 20A (~ m/c)]
Governor clearance not adjusted correctly	HI side (E/G stopped & key ON) ; Accel Hi check governor clearance 0.2mm (0.008") STOP side (E/G stopped & key ON) ; →Key off, less than 4sec governor clearance 0.1mm (0.004")
Key switch relay faulty	Check coil resistance. Sdtandard value: about 250Ω
Controller poor contact	Shake harnesses.

BooK code No. S5LE07 02E

KOBELCO

SHOP MANUAL SK60

WORKING STANDARD

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LE07

KOBE STEEL, LTD.

Applicable Machines
LE-11001~

Revjision	Date of Issue	Remarks
First edition	June,1990	S5LE0702E K

1. TIGHTENING TORQUES FOR CAPSCREWS AND NUTS

Tables 1 and 2 indicate tightening torques applicable to cases where no special note is given. Overtightening of bolts may result in a twist.off and a fracture under load. Undertightening may lead to a loosening or loss of bolts. Always tighten bolts to proper torques.

Table 1 Standard tightening torques for metric coarse screw threads kgf · m (ft-lbs)

Classification	4	T	7	T	10	T
Nominal size	No lubrication	Oil lubrication	No lubrication	Oil lubrication	No lubrication	Oil lubrication
M 6 P=1	0.45±0.05 (3.2 ±0.4)	0.38±0.04 (2.7±0.3)	0.98±0.1 (7.1±0.7)	0.83±0.08 (6.0±0.6)	1.77±0.18 (12.8±1.3)	1.5±0.15 (10.8±1.1)
M 8 P=1.25	1.09±0.11 (7.9±0.8)	0.92±0.09 (6.6±0.7)	2.4±0.2 (17.3±1.4)	2.0±0.2 (14.4±1.4)	4.3±0.4 (31.0±2.9)	3.6±0.4 (26.0±2.9)
M10 P=1.5	2.2±0.2 (15.9±1.4)	1.83±0.18 (13.2±1.3)	4.7±0.5 (33.9±3.6)	4.0±0.4 (28.9±2.9)	8.5±0.9 (61.3±6.5)	7.2±0.7 (52.0±5.1)
M12 P=1.75	3.7±0.4 (26.7±2.9)	3.2±0.3 (23.1±2.2)	8.1±0.8 (58.5±5.8)	6.8±0.7 (49.1±5.1)	14.6±1.5 (105±10.8)	12.3±1.2 (88.8±8.7)
M14 P=2	5.9±0.6 (42.6±4.3)	5.0±0.5 (36.1±3.6)	12.8±1.3 (92.5±9.4)	10.8±1.1 (78.0±7.9)	23±2 (166±14)	19.5±1.9 (140 ±14)
M16 P=2	9.0±0.9 (64.9±6.5)	7.6±0.7 (54.8±5.1)	19.5±2.0 (140±14.4)	16.4±1.6 (118±11.5)	35±4 (252±28.9)	29±3 (209±21.6)
M18 P=2.5	12.4±1.2 (89.6±8.7)	10.5±1.0 (75.8±7.2)	27±3 (195±22)	23±2 (166±14)	49±5 (354±36)	41±4 (296±29)
M20 P=2.5	17.5±1.7 (126±12.3)	14.7±1.4 (106±10.1)	38±4 (274±29)	32±3 (231±22)	68±7 (491±51)	57±6 (412±43)
M22 P=2.5	23±2 (166±14)	19.6±2.0 (142±14)	51±5 (368±36)	43±4 (310±29)	92±9 (663±65)	77±8 (555±58)
M24 P=3	30±3 (217±22)	24±3 (173±22)	65±7 (469±51)	53±5 (383±36)	118±12 (852±87)	96±10 (693±72)
M27 P=3	44±4 (318±29)	36±3 (260±22)	96±10 (693±72)	78±8 (563±58)	173±17 (1250±120)	140±14 (1010±100)
M30 P=3.5	60±6 (433±43)	50±5 (361±36)	131±13 (946±94)	110±11 (794±79)	235±24 (1700±170)	198±20 (1430±140)
M33 P=3.5	81±8 (585±58)	68±7 (491±51)	176±18 (1270±130)	148±15 (1070±110)	317±32 (2290±230)	266±27 (1920±200)
M36 P=4	105±10 (758±72)	88±9 (636±65)	227±23 (1640±170)	190±19 (1370±140)	409±41 (2950±300)	343±34 (2480±250)

Table 2 Standard tightening torques for metric fine screw threads kgf · m (ft-lbs)

Classification	4	T	7	T	10	T
Nominal size	No lubrication	Oil lubrication	No lubrication	Oil lubrication	No lubrication	Oil lubrication
M 8 P=1	1.15±0.11 (8.3±0.8)	0.97±0.1 (7.0±0.7)	2.5±0.2 (18.0±1.4)	2.1±0.2 (15.2±1.4)	4.5±0.4 (32.5±2.9)	3.8±0.4 (27.4±2.9)
M10 P=1.25	2.3±0.2 (16.6±1.4)	1.91±0.19 (13.8±1.4)	4.9±0.5 (35.4±3.6)	4.2±0.4 (30.3±2.9)	8.9±0.9 (64.2±6.5)	7.5±0.7 (54.2±5.1)
M12 P=1.25	4.0±0.4 (28.9±2.9)	3.4±0.3 (24.5±2.2)	8.7±0.9 (62.8±6.5)	7.3±0.7 (52.7±5.1)	15.7±1.6 (113±12)	13.2±1.3 (95.3±9.4)
M16 P=1.5	9.4±0.9 (67.9±6.5)	7.9±0.8 (57.0±5.8)	20±2 (144±14)	17.2±1.7 (124±12)	37±4 (267±29)	31±3 (224±22)
M20 P=1.5	19±1.9 (137±14)	15.8±1.6 (114±12)	41±4 (296±29)	34±3 (246±22)	74±7 (535±51)	62±6 (448±43)
M24 P=2	32±3 (231±22)	27±3 (195±22)	70±7 (506±51)	58±6 (419±43)	126±12 (910±87)	105±10 (758±72)
M30 P=2	65±6 (469±43)	54±5 (390±36)	142±14 (1030±100)	118±12 (852±87)	255±26 (1840±190)	212±21 (1530±150)
M36 P=3	109±11 (787±79)	91±9 (657±65)	238±23 (1720±170)	198±20 (1430±140)	428±43 (3090±310)	357±36 (2580±260)

2. TIGHTENING TORQUES FOR NUTS AND SLEEVES

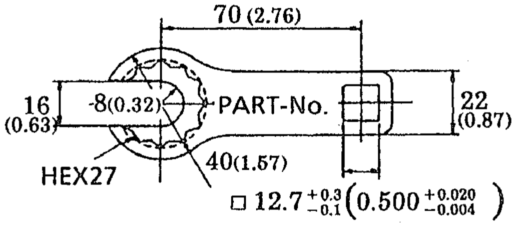
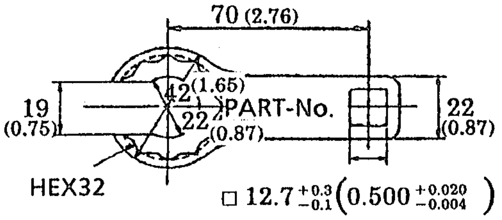
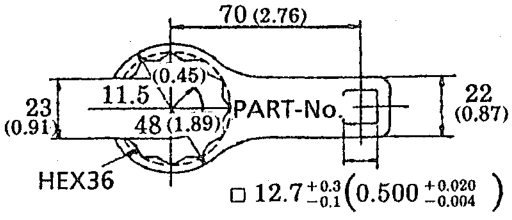
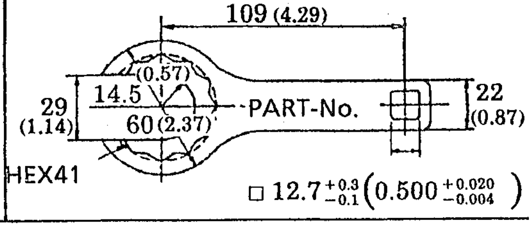
Table 3 indicates standard tightening torques applicable to cases where no particular note is given. Overtightening or undertightening of nuts and sleeves in bite type tube fittings may develop oil leaks through pipe connections. Always tighten nuts and sleeves to proper torques.

Table 3

Manufacturer's name	Working pressure kgf / cm^2 (psi)	Tube size OD×thickness mm (in)	Tightening torque kgf·m (ft·lbs)
Nippon A.M.C.	300 (4270)	10×1.5 (0.394×0.059)	6.5±0.5 (46.9±3.6)
		15×2.0 (0.591×0.079)	11.5±0.5 (83.1±3.6)
		18×2.5 (0.709×0.098)	18±2 (130±14.4)
		22×3.0 (0.866×0.118)	22±2 (159±14)
		28×4.0 (1.10×0.157)	28±3 (202±22)
Ihara Koatu	300 (4270)	35×5.0 (1.38×0.20)	35±3.5 (253±25)

3. SPECIAL SPANNER FOR TUBE

Table 4

Applicable tube diameter mm (in)	Part No	Opposing flats of a hex-agon nut mm (in)	Drawing of a special spanner (in)
15 (0.59)	2421T160	27 (1.06)	 70 (2.76) 16 (0.63) 8 (0.32) PART-No. 22 (0.87) 40 (1.57) HEX27 □ 12.7$^{+0.3}_{-0.1}$ (0.500$^{+0.020}_{-0.004}$)
18 (0.71)	2421T138	32 (1.26)	 70 (2.76) 42 (1.65) 19 (0.75) 22 (0.87) PART-No. 22 (0.87) HEX32 □ 12.7$^{+0.3}_{-0.1}$ (0.500$^{+0.020}_{-0.004}$)
22 (0.87)	2421T130	36 (1.42)	 70 (2.76) 11.5 (0.45) 23 (0.91) 48 (1.89) PART-No. 22 (0.87) HEX36 □ 12.7$^{+0.3}_{-0.1}$ (0.500$^{+0.020}_{-0.004}$)
28 (1.10)	2421T115	41 (1.61)	 109 (4.29) 14.5 (0.57) 29 (1.14) 60 (2.37) PART-No. 22 (0.87) HEX41 □ 12.7$^{+0.3}_{-0.1}$ (0.500$^{+0.020}_{-0.004}$)

4. APPLICATION TABLE OF SCREW LOCKING AND SEALING COMPOUNDS

Table 4

MANUFACTURER	LOCKTITE	THREE-BOND
BRAND NAME	# 242	1360K
	# 262	1305
	# 271	1305
	# 515	1215

SHOP MANUAL

model SK60

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4. TRAVEL SYSTEM LE18
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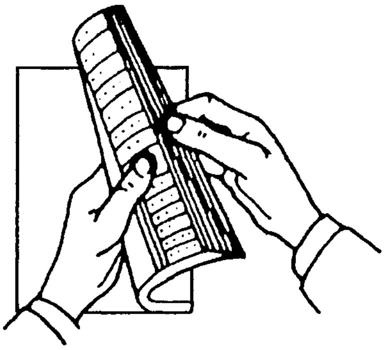
○How to Index each Shop Manual Section
The SYSTEMS of this shop manual consists of 9 headings as shown above. Each section can be easily referred to by indexes appended to the margin of the page as indicated on the right. Please use the indexes for speedy reference.



KOBELCO

SYSTEMS

Book code No. S5LE1005E②

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LE12	HYDRAULIC SYSTEM	S5LE1206E① 1990-10	←	
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LE18	TRAVEL SYSTEM	S5LE1806E 1990-6	←	
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BooK code No. S5LE1105E

KOBELCO

SHOP MANUAL SK60

LE11

DRIVE SYSTEM

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KOBE STEEL, LTD.

Applicable Machines
LE11001~

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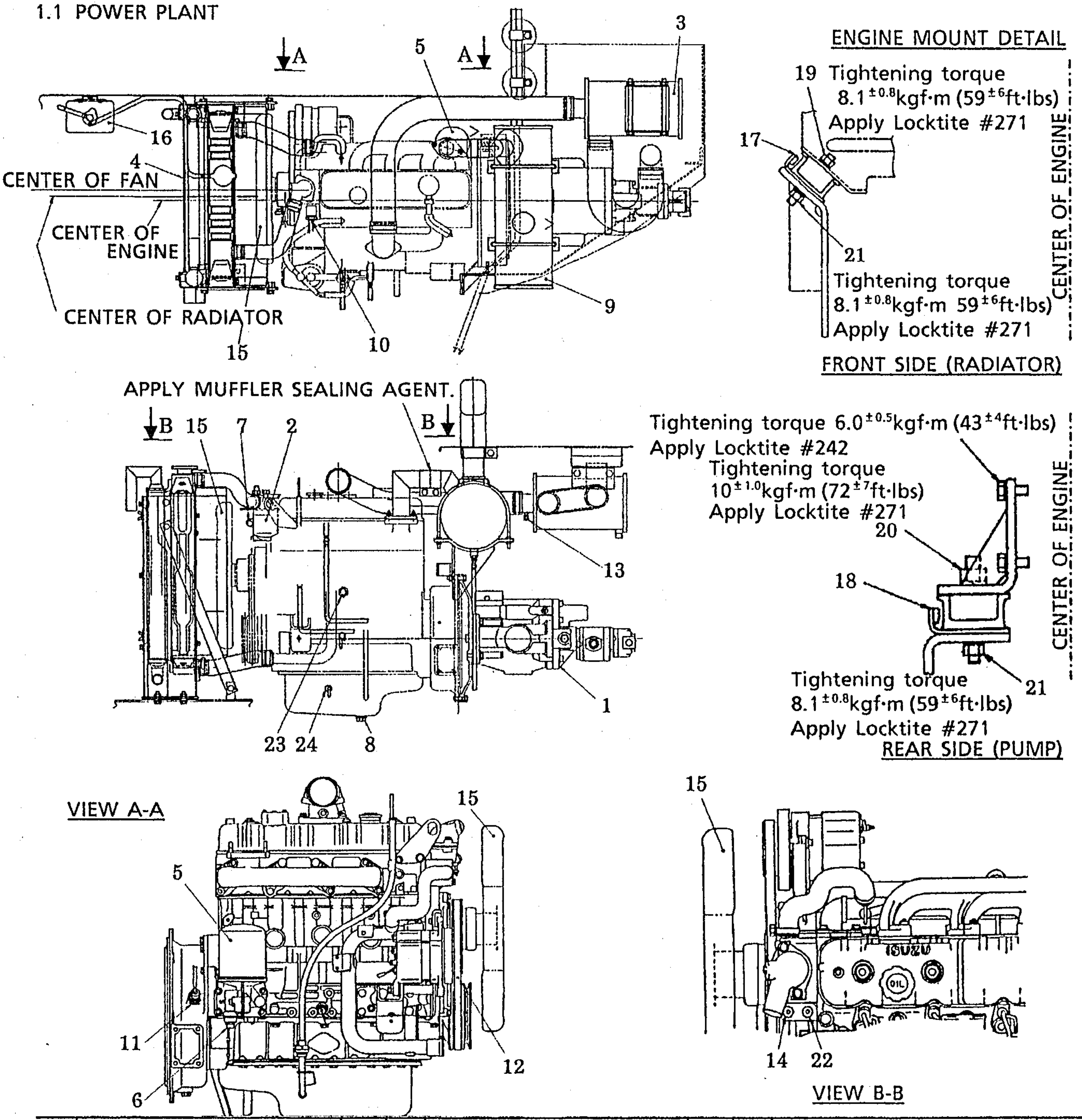
First edition	June, 1990	S5LE1105E K

1. GENERAL

1.1 POWER PLANT


A
A
B
B
3
5
16
4
CENTER OF FAN
CENTER OF ENGINE
CENTER OF RADIATOR
15
10
9
ENGINE MOUNT DETAIL
19
17
21
CENTER OF ENGINE
FRONT SIDE (RADIATOR)
APPLY MUFFLER SEALING AGENT.
15
7
2
13
1
23
24
8
20
18
21
CENTER OF ENGINE
REAR SIDE (PUMP)
VIEW A-A
5
15
11
6
12
15
ISUZU
OIL
14
22
VIEW B-B

Tightening torque $8.1^{\pm0.8}$kgf·m ($59^{\pm6}$ft·lbs)
Apply Locktite #271

Tightening torque $8.1^{\pm0.8}$kgf·m $59^{\pm6}$ft·lbs)
Apply Locktite #271

Tightening torque $6.0^{\pm0.5}$kgf·m ($43^{\pm4}$ft·lbs)
Apply Locktite #242

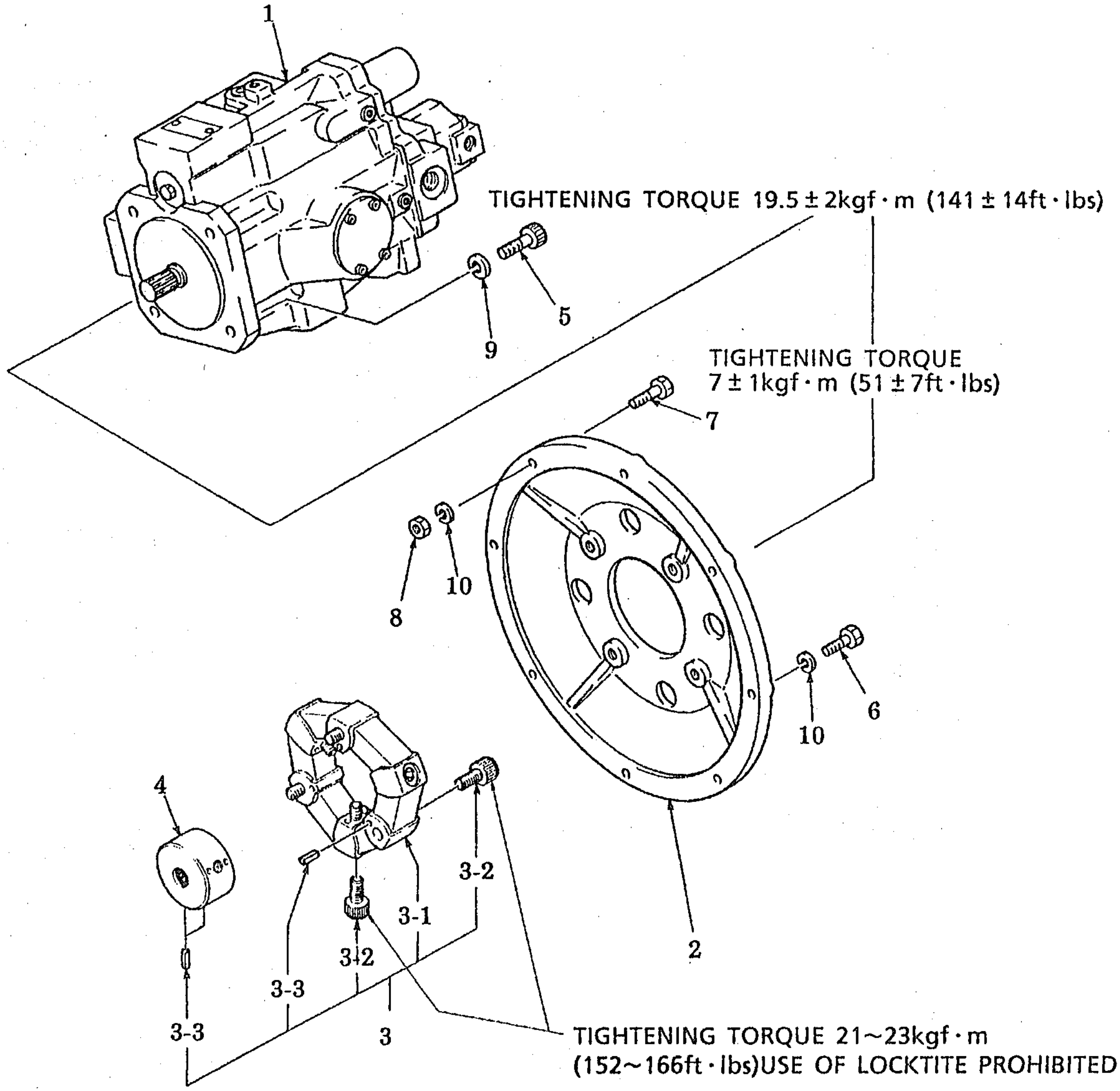
Tightening torque $10^{\pm1.0}$kgf·m ($72^{\pm7}$ft·lbs)
Apply Locktite #271

Tightening torque $8.1^{\pm0.8}$kgf·m ($59^{\pm6}$ft·lbs)
Apply Locktite #271

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
1	PUMP CONNECTION ASSY	1	10	THERMO SENDING GAUGE UNIT	1	18	CUSHION RUBBER (REAR)	2
2	FUEL FILTER	1	11	TACHOMETER SENSOR	1	19	NUT·WASHER	2set
3	AIR CLEANER	1	12	FAN BELT	1	20	NUT·WASHER	2set
4	RADIATOR ASSY	1	13	DUST INDICATOR	1	21	NUT·WASHER	4set
5	OIL FILTER	1	14	HEATING WATER TAKE OUT	1	22	HEATING WATER RETURN	1
6	OIL FILTER CLOGGED SENSOR	1	15	FAN	1	23	WATER DRAIN PLUG	1
7	OIL PRESSURE SWITCH	1	16	RADIATOR SUB TANK	1	24	OIL LEVEL SENSOR	1
8	OIL PAN DRAIN PLUG	1	17	CUSHION RUBBER (FRONT)	2			
9	MUFFLER	1						

Fig. 1 Outside view and designation of power plant

1.2 PUMP CONNECTION


1
TIGHTENING TORQUE 19.5 ± 2kgf · m (141 ± 14ft · lbs)
5
9
TIGHTENING TORQUE
7 ± 1kgf · m (51 ± 7ft · lbs)
7
10
8
6
10
4
3-2
3-1
3-2
2
3-3
3-3
3
TIGHTENING TORQUE 21~23kgf · m
(152~166ft · lbs)USE OF LOCKTITE PROHIBITED

No.	NAME	Q'ty	No.	NAME	Q"ty	No.	NAME	Q'ty
1	PUMP ASSY	1	3-3	SPRING PIN	9	8	NUT	3
2	BRACKET	1	4	COUPLING HUB	1	9	LOCK WASHER	4
3	COUPLING ASSY	1	5	CAPSCREW	4	10	LOCK WASHER	8
3-1	CUSHION RUBBER	1	6	CAPSCREW	5			
3-2	SOCKET BOLT	6	7	CAPSCREW	3			

Fig. 2 Pump connection construction drawing

Although the body of pump ass'y (1) is fixed to the flywheel of the engine via bracket (2), the drive shaft (input shaft) is constantly connected to the flywheel of the engine by means of coupling ass'y (3).

Shocks produced by abrupt variation in the load between the engine and the pump are absorbed by coupling ass'y (3) of the pump connection. In addition, the machine has an increased inertial moment of the engine flywheel to lessen uneven rotation at low speed as much as possible so that impact load torque acting upon coupling ass'y (3) decreases.

☞ When fitting pump ass'y to the engine, coat the spline of the input shaft with Shell Resinux AM grease or equivalent to an extent that it does not flow over the hub.

2. REMOVAL AND INSTALLATION OF HYDRAULIC PUMP

2.1 REMOVING HYDRAULIC PUMP

1) After stopping the engine, remove the guard and the bracket above the hydraulic pump.

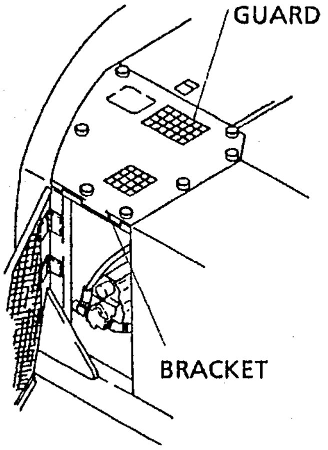


Fig. 3 Remove the guard and bracket

2) Install the suction stopper on the suction port of the hydraulic oil tank.

⚠ Be sure to loosen the air breather and bleed any residual pressure from the tank before removing the tank cover and flange.

☞ For details of the suction stopper, refer to "Details of Suction Stopper."

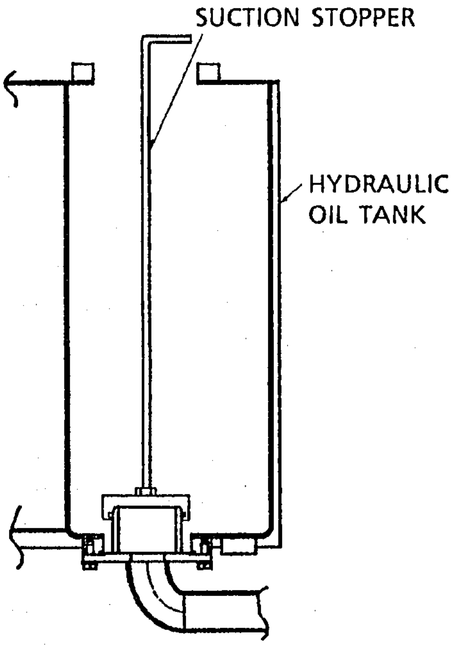


Fig. 4 Install the suction stopper

3) Disconnect all tubes and hoses from the hydraulic oil tank, such as the suction tube, delivery hose, drain hoses, and pilot hose. Plug each hose, tube, and hydraulic pump port.

4) Loosen slightly the 4 hex socket head bolts (5) holding the pump.

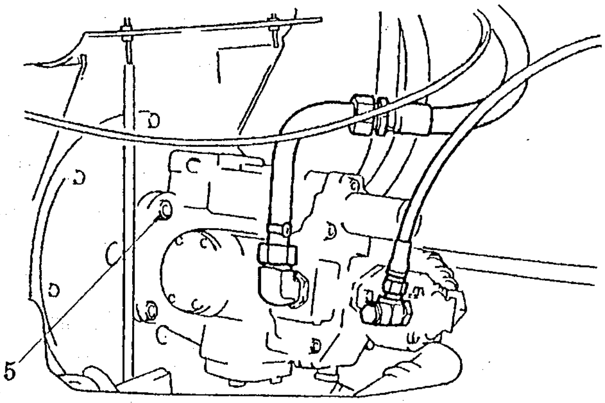


Fig. 5 Hydraulic oil pump

5) Place a wire sling around the center of hydraulic pump, lift it to an extent that the wire sling does not slack and remove four capscrews (5).

6) Slacken the wire sling a little, draw out hydraulic pump (1) slowly toward yourself, make sure that the drive shaft of the pump is off coupling hub (4) and lift up hydraulic pump (1) till it comes off.

☞ When removing hydraulic pump (1), exercise care so as not to hit the pump against the guard frame and others.

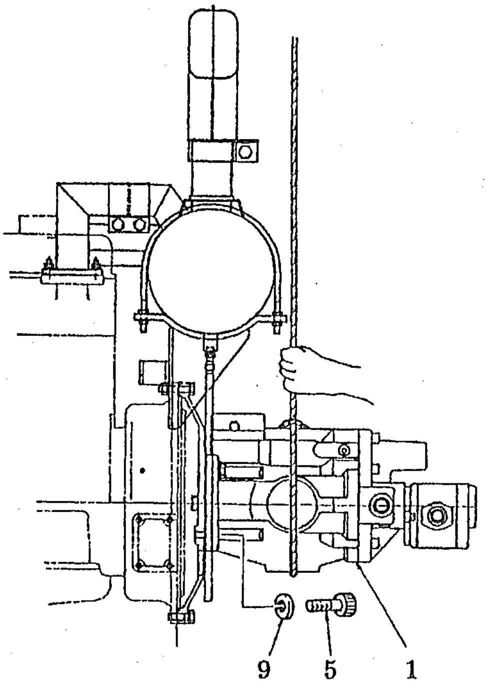


Fig. 6 Dismantling the pump ass'y

2.2 INSTALLING HYDRAULIC PUMP

1) Remove burr and stain on the mounting flange face of hydraulic pump (1) and the mounting surface of bracket (2).

2) Coat the drive shaft spline of hydraulic pump (1) with a thin film of a designated grease (to an extent that grease does not come out of the hub.).

3) Place a wire sling around hydraulic pump (1), lift it up level and set it in the mounting position of the pump.

☞ When setting hydraulic pump (1), exercise care so as not to bump it against the guard frame, etc.

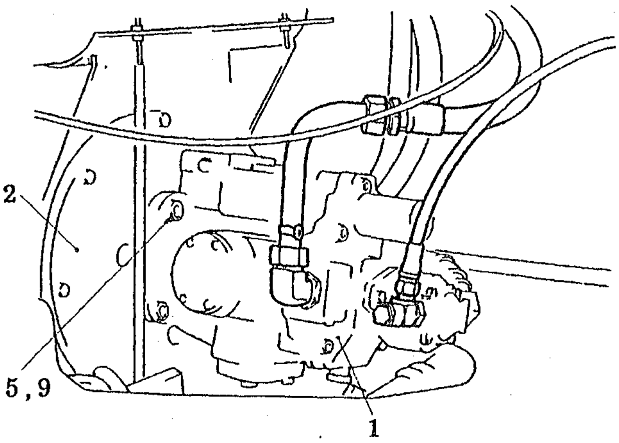


Fig. 7 Mounting the pump ass'y

4) Confirm that the drive shaft spline of hydraulic pump (1) is correctly fixed to the spline of coupling hub (4). Then press hydraulic pump (1) toward the engine.

5) Match the holes in the mounting flanges of bracket (2) and the hydraulic pump, fit washers (9) to four capscrews (5) and tighten them to a specified torque.

3. REMOVAL AND INSTALLATION OF COUPLING

3.1 REMOVING COUPLING

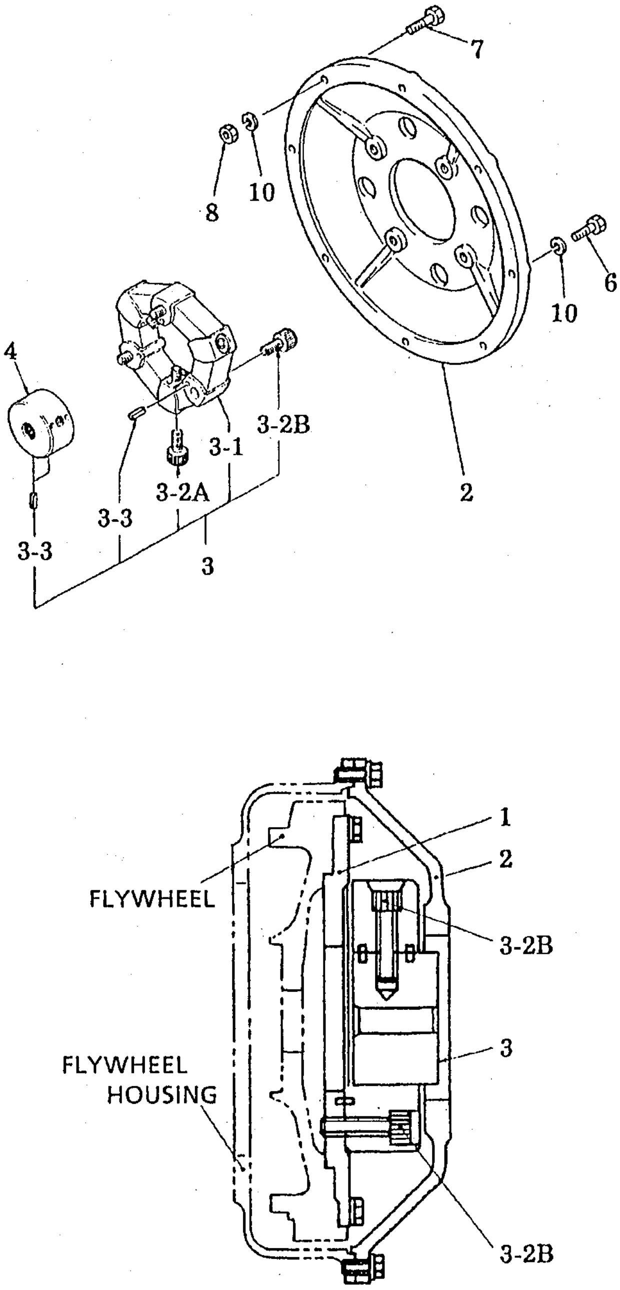
1) Remove the bracket of the air cleaner fastened with capscrews (7), remove capscrews (6) and then dismantle bracket (2) from the flywheel housing.
2) Loosen the socket head capscrew (3-2B) and separate coupling ass'y (3) from flange (1) of the flywheel.
3) Loosen the socket head capscrew (3-2A) and separate coupling hub (4) from cushion cover (3-1).
4) Separate spring pin (3-3) from coupling ass'y (3).

3.2 INSTALLING THE COUPLING

1) Attach spring pin (3-3) to coupling hub (4) and put it into the cushion rubber (3-1).
2) Tighten socket head capscrew (3-2A) to a specified torque and assemble hub (4) with cushion rubber (3-1) to make up coupling ass'y (3).
3) Fit coupling ass'y (3) to flanged (1) and fasten them together with socket head capscrews (3-2B) to a specified torque.

☞ ●Do not apply Locktite to socket head capscrews (3-2A) and (3-2B).
●Spring pin (3-3) may be reused if not faulty.

4) Fit bracket (3) and the air cleaner bracket fastened with the bracket (3) to the flywheel housing and tighten them with capscrews (6) and (7).



No.	NAME	Q'ty	No.	NAME	Q'ty
1	FLANGE	1	3-3	SPRING PIN	6
2	BRACKET	1	4	COUPLING HUB	1
3	COUPLING ASSY	1	6	CAPSCREW	5
3-1	CUSHION RUBBER	1	7	CAPSCREW	3
3-2A	SOCKET BOLT	3	8	NUT	3
3-2B	SOCKET BOLT	3	10	LOCK WASHER	8

Fig. 8 Removal and installation of coupling

4. REMOVAL AND INSTALLATION OF RADIATOR

4.1 REMOVING RADIATOR

1) Remove the guard over the engine and the right and left covers.
2) Open the drain plug of the radiator (13) to drain the cooling water from the engine and radiator.
3) Remove the cap screws (39, 48) to remove the RH and LH stays (14).
4) Remove the sems-bolt (6) to remove the fan guard (20). (O. P. T)
5) Lift the wire sling to an extent that it does not slack, utilizing the metal fitting at the top of the radiator frame.
6) Disconnect all hoses between the engine, the radiator and the sub tank and remove the fastening bolts of the air conditioner capacitor.
7) Remove the radiator mounting cap screws (39).

☞ When removing the radiator, use care so that it does not interfere with the engine fan.

4.2 INSTALLING RADIATOR

1) Place sound insulation material (53, 54, 60, 61, 62, 63, 64, 71) around the radiator.

☞ Check that the sound insulation material is not deformed and damaged and replace it as necessary.

2) Lift the radiator with a lifting device, install it on the mounting face, and temporarily fix it with the cap screws (39).
3) Fit RH and LH stays (14) between the radiator and the upper frame mount and fasten them together with capscrews (39, 48).
4) Fasten the fan guard (20) with the sems-bolt (6). (O. P. T)
5) In accordance with the Maintenance Standards, adjust the clearance between the fan and the shroud, make sure the radiator is perpendicular, then tighten the cap screws (39A, 39B, 48) to the specified torque.
6) Attach hoses and condenser mounting bolts between radiator (13) and the engine.
7) Install the hose (65) between the radiator (13) and the subtank (28).
8) Turn up the drain plug and fill cooling water to a specified level according to the maintenance instructions of the Operation Manual for Standard Machines.
9) Run the engine for about ten minutes and make sure that no water is leaking from the hoses and through connections.
10) Stop the engine. Check the water level in the subtank, and add more water if necessary.

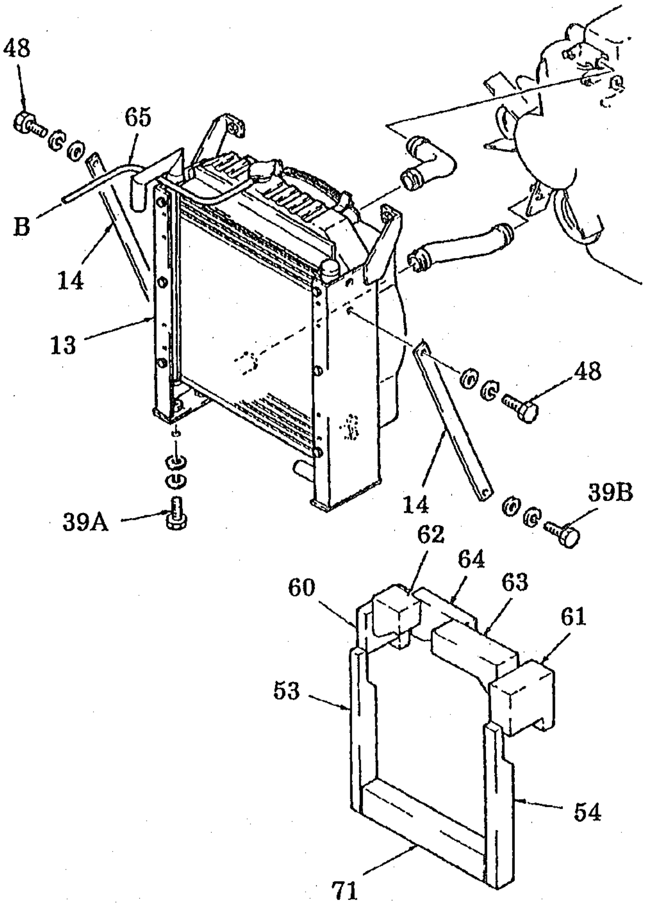


Fig. 9 Radiator assembly

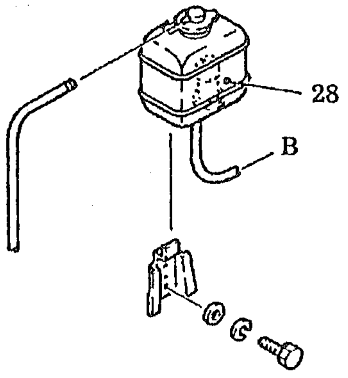


Fig. 10 Radiator subtank

5. MAINTENANCE STANDARDS

5.1 PUMP CONNECTION

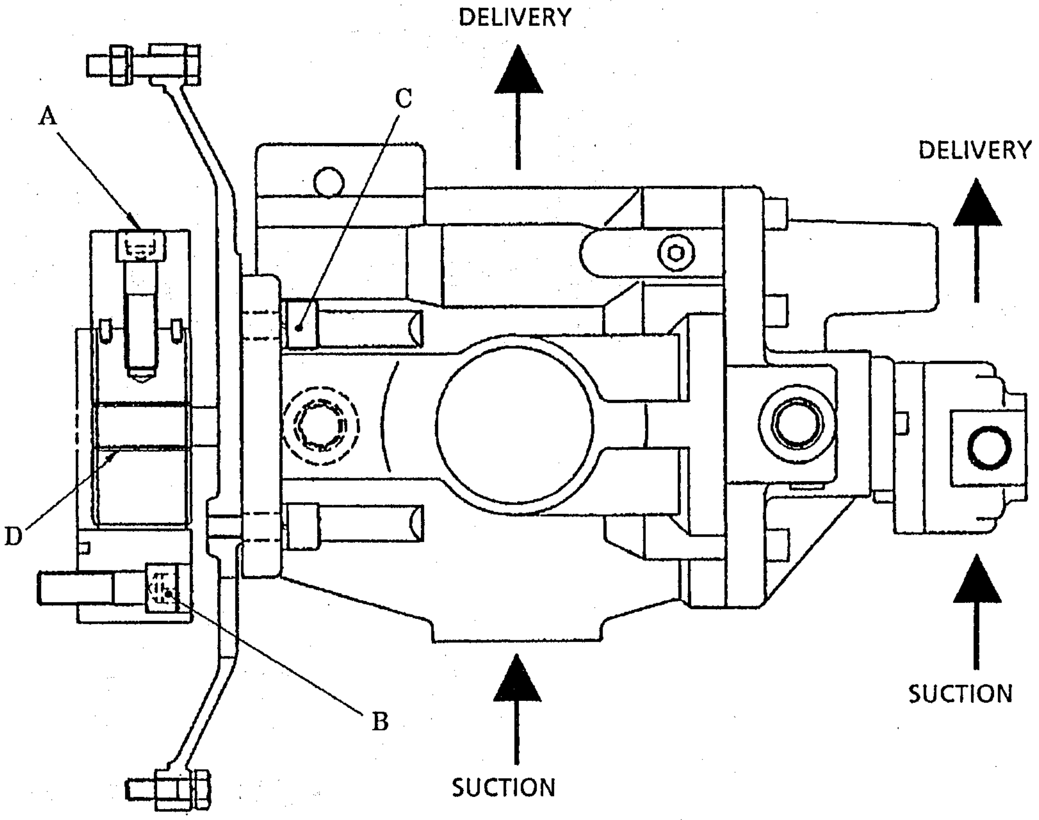
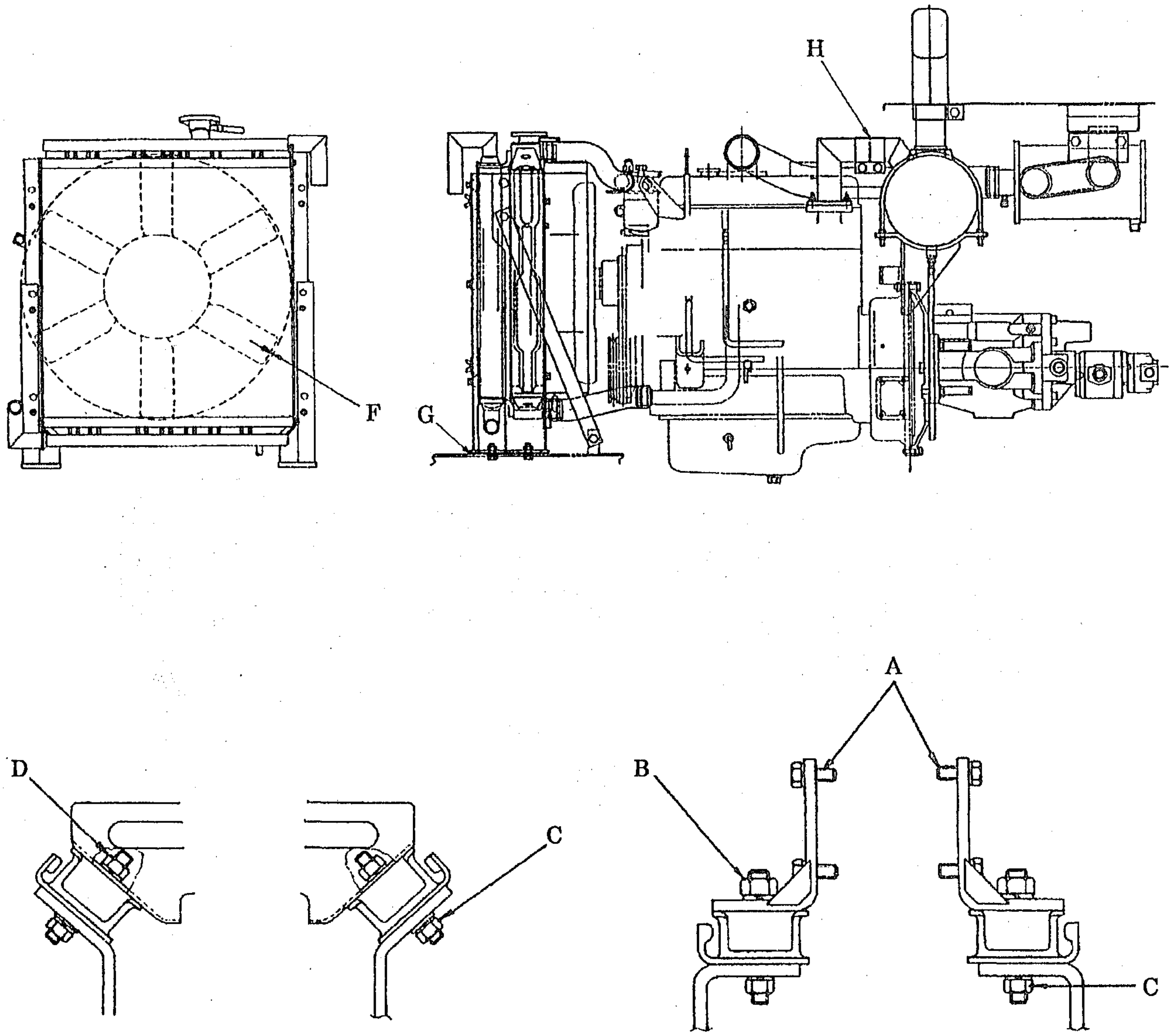


Fig. 11 Coupling

Table 1 Unit: kgf·m (ft·lbs)

Symbol	Item	Standard Value	Remedy
A	SOCKET BOLT	21~23 (152~166)	•Do not apply Locktite. •Retighten.
B	SOCKET BOLT		
C	CAPSCREW	19.5±2 (141±14)	•Apply Locktite #242.
D	Coat the input shaft and the spline of the pump with Shell Resinux AM grease (or equivalent) to an extent that grease does not come out of the hub.		

5.2 INSTALLING ENGINE MOUNT AND RADIATOR



FRONT SIDE (FAN SIDE)

REAR SIDE (PUMP SIDE)

Fig. 12 Engine mount and radiator

Table 2

Unit: kgf · m (ft · lbs)

Symbol	Item	Reference value	Remark
A	Rear engine mount bracket mounting capscrew	6.0±0.5 (43±4)	●Apply Locktite #242
B	Rear engine mount and cushion rubber mounting nut (upper)	10.0±1 (72±7)	●Apply Locktite #271
C	Rear and front engine mounts and cushion rubber mounting nut (lower)	8.1±0.8 (59±6)	
D	Front engine mount and cushion rubber fastening nut (upper)		
E	Muffler mounting U-bolt not	2.4±0.5 (17±4)	Retighten
F	Adjusted dimension of fan and radiator shroud	20^{+5}_{0} (144^{+36}_{0})	Adjust section G, using shims.
H	Apply muffler sealing compound.		

6. DETAILS OF SUCTION STOPPER

6.1 COMPONENTS OF SUCTION STOPPER

No.	NAME	PARTS No.	Q'ty
	Suction stopper assy	24100P978F2	
1	Rod	2420T4660D1	1
2	Nut	ZN16C08007	1
3	Cover	2414T2123D2	1
4	O ring	45Z91D6	1

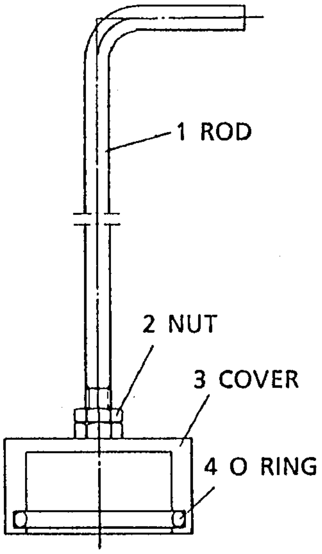
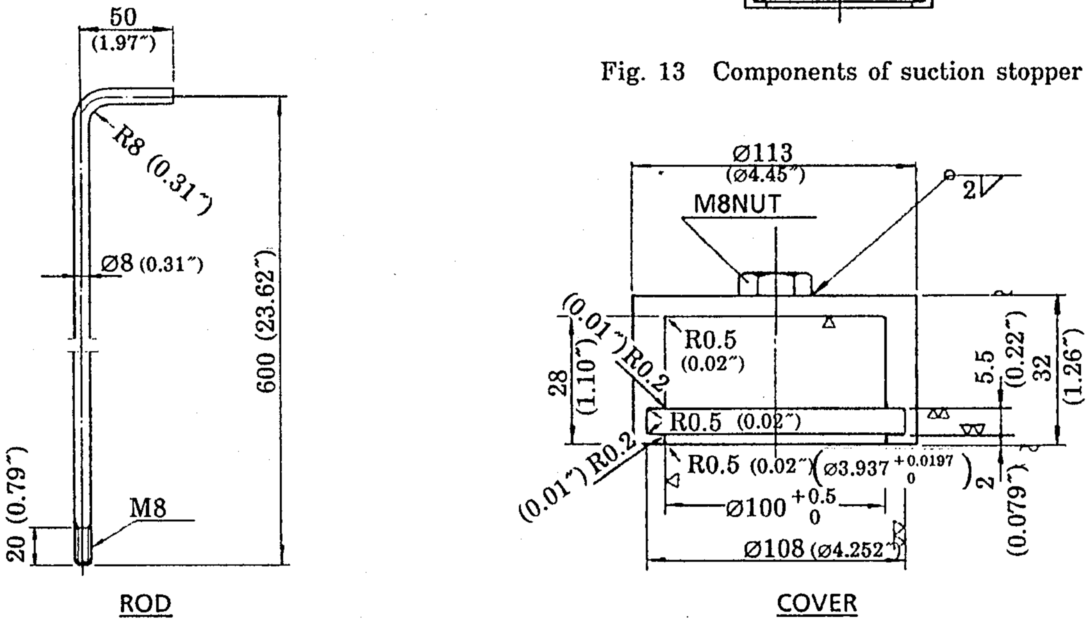

1 ROD
2 NUT
3 COVER
4 O RING

Fig. 13 Components of suction stopper

6.2 DIMENSION OF SUCTION STOPPER


50
(1.97")
R8 (0.31")
Ø8 (0.31")
600 (23.62")
20 (0.79")
M8
Ø113
(Ø4.45")
M8NUT
2▽
(0.01")R0.2
R0.5
(0.02")
28
(1.10")
R0.5 (0.02")
(0.01")R0.2
R0.5 (0.02")(Ø3.937 +0.0197 0)
Ø100 +0.5 0
Ø108 (Ø4.252")
5.5
(0.22")
32
(1.26")
2
(0.079")

ROD

COVER

Fig. 14 Dimension of suction stopper

6.3 MACHINE MODELS TO WHICH SUCTION STOPPER IS APPLICABLE

Table 5

PART No. OF SUCTION STOPPER	APPLICABLE MODEL		
	SK SERIES	K SERIES	YS SERIES
24100P978F2	SK03,SK035,SK04,SK04L, SK04W,SK05,SK07,SK07LC, SK10,SK12,SK20,SK07-2, SK07LC-2,SK04-2,SK04L-2, SK07-N2,SK07LC-N2, SK03-N2,SK045-N2, SK04-N2,SK100W,SK200 SK220,SK100,SK120,SK60	K904SS,K905,K907B, K909,K910,K912, K914,K935 K904-II ,K905-II , K905LC-II ,K907-II , K907LC-II ,K909-II , K909LC-II ,	YS450C-C,YS450C,L,W-1,2, YS500,YS750-1,-2,YS1000-2, YS1200-2,YS1400-1,-2,-3, YS2000

☞ ● 2 sets of 24100P978F2 are needed for K909 and K914.

BooK code No. S5LE1206E

KOBELCO

SHOP MANUAL SK60

HYDRAULIC SYSTEM

LE12

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KOBE STEEL, LTD.

Applicable Machines
LE-11001~

		NORTH AMERICA			NORTHEN EUROPA			EUROPA					CUSTOMER'S COUNTRY							
	PAGE	KAI			FINLAND	NORWAY	SWEDEN	DENMARK	ENGLAND	HOLLAND BELGIUM PORTUGAL	AUSTRIA	SWISS	CENTRAL SOUTH AMERICA	NEW ZEALAND	AUSTRALIA	TAIWAN	CHINA	NEAR MIDDLE AFRICA		
SELECT PAGE	1	–			B	B	B	B	B	B	B	B	A	A	A	A	A	A		
	2	–			B	B	B	B	B	B	B	B	A	A	A	A	A	A		
	3,4	–			B	B	B	B	B	B	B	B	A	A	A	A	A	A		
	31,32	–			○	○	○	○	○	○	○	○	–	–	–	–	–	–		

Revision	Date of Issue	Remarks
First edition	March, 1990	S5LE1206E K

1. GENERAL

This machine incorporates the features and functions described below in its hydraulic circuitry in order to provide easier operation, greater safety, higher productivity, and better fuel economy.

Standard Spec.

Table 1A

Objective	Component	Function	Feature
Ease of operation, and safety	Travel	● Straight travel	● Straight travel during simultaneous operations
		● Travel boost pressure	● Maximum travel relief pressure
	Swing	● Swing flasher signal light	● Warning to those near the machine during simultaneous operations
		● Independent swing control valve	● Better swing control
		● Swing priority circuit (during simultaneous swing and arm retraction)	● Easier digging thanks to the use of simultaneous swing and arm retraction
		● Automatic swing brake	● Out-of-control swing prevented on slopes
		● Delayed swing braking controlled by reducing valve	● Delayed swing brake application during swing due to inertia
		● Anti-swing-back function controlled by swing shockless valve	● Easier machine positioning due to swing-back being prevented after swing due to inertia
	Attachments	● Control by pilot pressure	● Fine-tuned operation
		● FC mode changeover	● Delicate controllability
	Miscellaneous	● Hydraulic tank is closed type and semi-automatically pressurized	● Contamination of hydraulic oil prevented, self-suction ability of pump improved
		● Suction strainer	● Failure of hydraulic components prevented
		● Return line: filter element and drain filter	● Contamination of hydraulic oil prevented
		● Pilot circuit: line filter	● Pilot-operated circuit failure prevented
		● Hydraulic oil cooled by oil cooler	● Deterioration of hydraulic oil prevented
Productivity increased	Pump	● Full horsepower control	● Effective use of engine horsepower through action of two variable displacement pumps
	Travel	● Automatic 2-speed travel by the 2-speed travel motor	● Tractive force matching a travel speed as fast as 5.5 kg/h and road surface.
	Attachments	● Conflux for boom raising	● Faster boom raising
		● Conflux circuit for arm retraction under heavy load	● Faster arm retraction under heavy load
		● Arm digging light load fixed recycle circuit	● Faster arm retraction under light load
		● Conflux circuit for arm extension	● Faster arm extension
Fuel economy	Pump	● FC mode changeover	● Decrease in pump delivery
	Micro computer	● KPSS 3 work mode switch changeover	● Selecting an effective engine revolution suited for the amount of work, fuel consumption and fine control.
		● Auto accel selection	● Engine speed varied during dumping wait state for reduced fuel bills and less noise

1. GENERAL

This machine incorporates the features and functions described below in its hydraulic circuitry in order to provide easier operation, greater safety, higher productivity, and better fuel economy.

Standard Spec.

Table 1B

Objective	Component	Function	Feature
Ease of operation, and safety	Travel	◉ Control by pilot pressure ◉ Straight travel ◉ Travel boost pressure	◉ Straight travel during simultaneous operations ◉ Maximum travel relief pressure
	Swing	◉ Swing flasher signal light ◉ Independent swing control valve ◉ Swing priority circuit (during simultaneous swing and arm retraction) ◉ Automatic swing brake ◉ Delayed swing braking controlled by reducing valve ◉ Anti-swing-back function controlled by swing shockless valve	◉ Warning to those near the machine during simultaneous operations ◉ Better swing control ◉ Easier digging thanks to the use of simultaneous swing and arm retraction ◉ Out-of-control swing prevented on slopes ◉ Delayed swing brake application during swing due to inertia ◉ Easier machine positioning due to swing-back being prevented after swing due to inertia
	Attachments	◉ Control by pilot pressure ◉ FC mode changeover ◉ Doger and Extra hyd.	◉ Fine-tuned operation ◉ Delicate controllability
	Miscellaneous	◉ Hydraulic tank is closed type and semi-automatically pressurized ◉ Suction strainer ◉ Return line: filter element and drain filter ◉ Pilot circuit: line filter ◉ Hydraulic oil cooled by oil cooler	◉ Contamination of hydraulic oil prevented, self-suction ability of pump improved ◉ Failure of hydraulic components prevented ◉ Contamination of hydraulic oil prevented ◉ Pilot-operated circuit failure prevented ◉ Deterioration of hydraulic oil prevented
Productivity increased	Pump	◉ Full horsepower control	◉ Effective use of engine horsepower through action of two variable displacement pumps
	Travel	◉ Automatic 2-speed travel by the 2-speed travel motor	◉ Tractive force matching a travel speed as fast as 5.5 kg/h and road surface.
	Attachments	◉ Conflux for boom raising ◉ Conflux circuit for arm retraction under heavy load ◉ Arm digging light load fixed recycle circuit ◉ Conflux circuit for arm extension	◉ Faster boom raising ◉ Faster arm retraction under heavy load ◉ Faster arm retraction under light load ◉ Faster arm extension
Fuel economy	Pump	◉ FC mode changeover	◉ Decrease in pump delivery
	Micro computer	◉ KPSS 3 work mode switch changeover ◉ Auto accel selection	◉ Selecting an effective engine revolution suited for the amount of work, fuel consumption and fine control. ◉ Engine speed varied during dumping wait state for reduced fuel bills and less noise

2. HYDRAULIC SYSTEM DIAGRAM

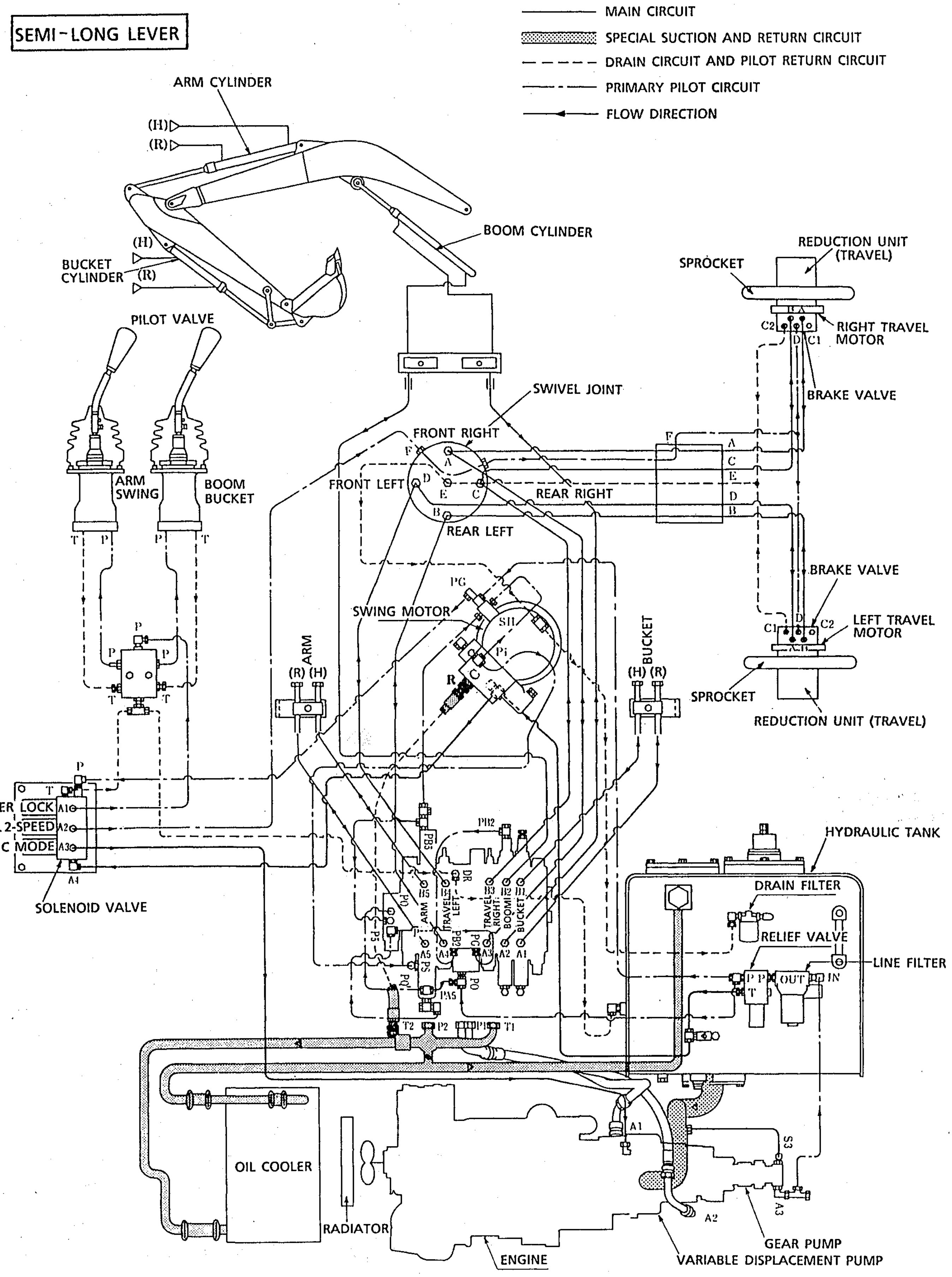

SEMI-LONG LEVER
MAIN CIRCUIT
SPECIAL SUCTION AND RETURN CIRCUIT
DRAIN CIRCUIT AND PILOT RETURN CIRCUIT
PRIMARY PILOT CIRCUIT
FLOW DIRECTION
ARM CYLINDER
(H)
(R)
BOOM CYLINDER
BUCKET CYLINDER
PILOT VALVE
ARM
SWING
BOOM
BUCKET
T
P
SWIVEL JOINT
FRONT RIGHT
FRONT LEFT
REAR RIGHT
REAR LEFT
A
B
C
D
E
F
SWING MOTOR
PG
SH
Pi
R
REDUCTION UNIT (TRAVEL)
SPROCKET
RIGHT TRAVEL MOTOR
C1
C2
BRAKE VALVE
LEFT TRAVEL MOTOR
LEVER LOCK
TRAVEL 2-SPEED
F C MODE
A1
A2
A3
A4
SOLENOID VALVE
PB2
PB5
PS
PO
PQ'
PC
PA5
DR
B1
B2
B3
B5
A5
TRAVEL LEFT
TRAVEL RIGHT
T1
T2
P1
P2
HYDRAULIC TANK
DRAIN FILTER
RELIEF VALVE
LINE FILTER
OUT
IN
OIL COOLER
RADIATOR
ENGINE
S3
GEAR PUMP
VARIABLE DISPLACEMENT PUMP

Fig. 1A Diagram of Major Hydraulic Circuits

WRIST CONTROL LEVER

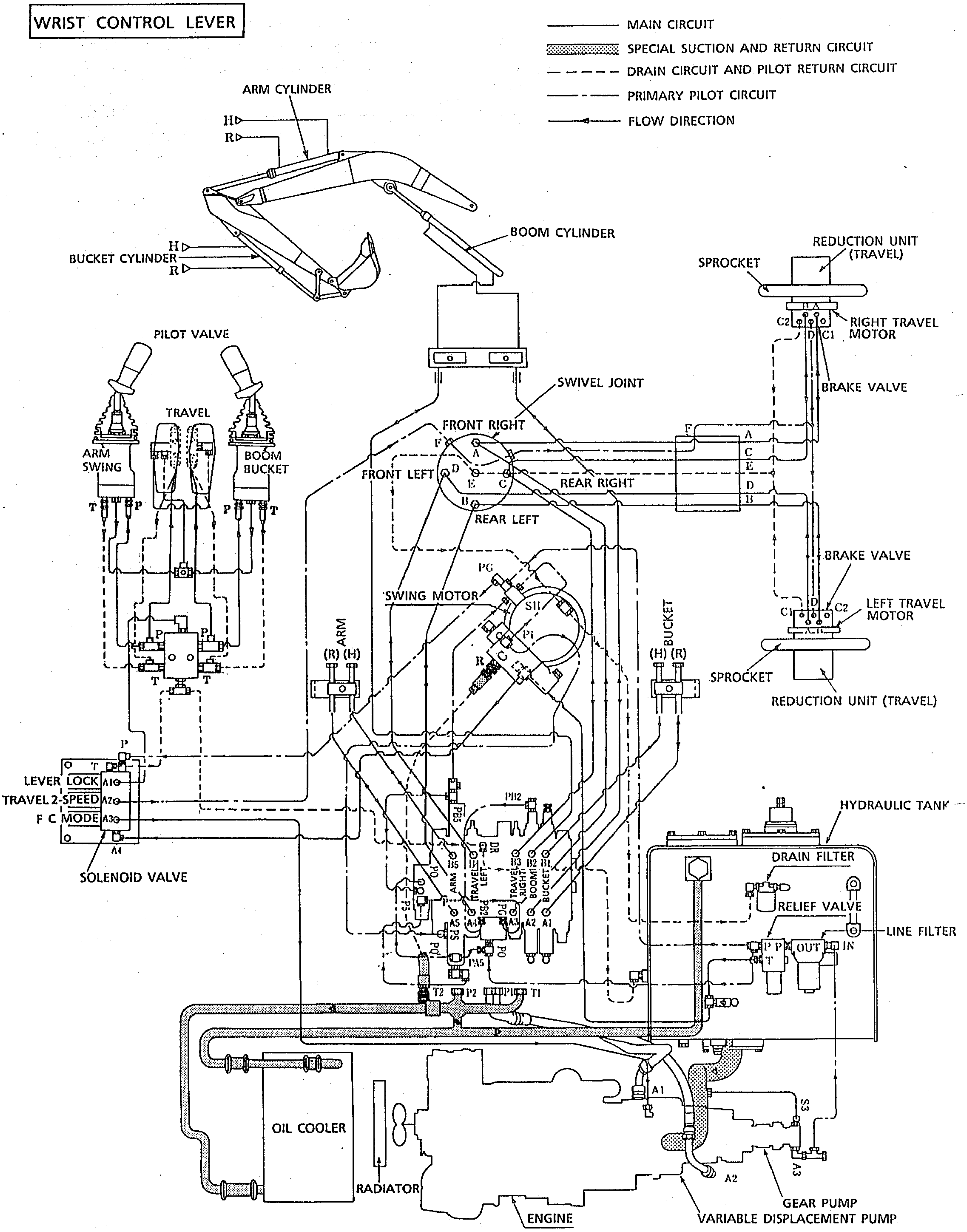
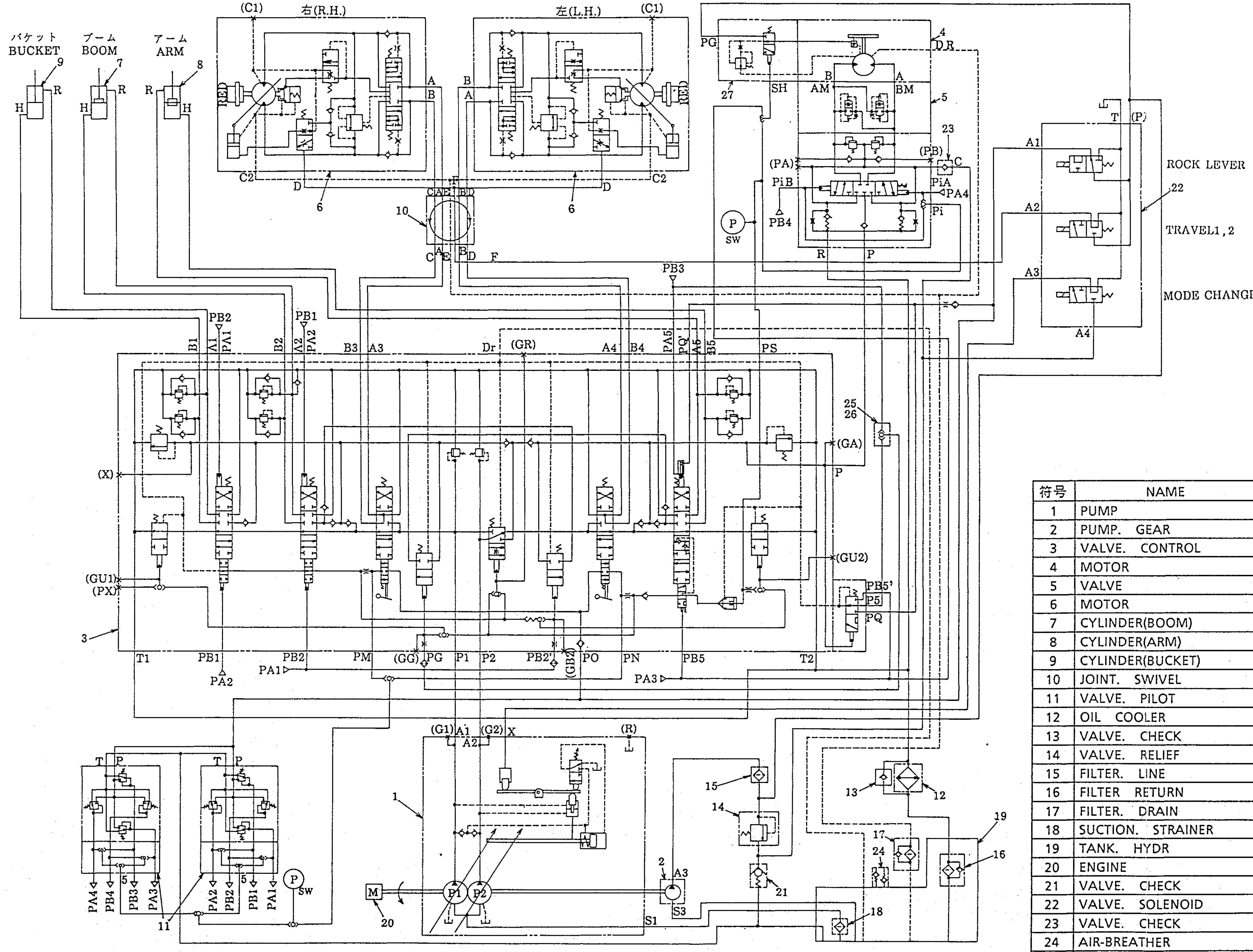

MAIN CIRCUIT
SPECIAL SUCTION AND RETURN CIRCUIT
DRAIN CIRCUIT AND PILOT RETURN CIRCUIT
PRIMARY PILOT CIRCUIT
FLOW DIRECTION
ARM CYLINDER
H
R
BOOM CYLINDER
H
BUCKET CYLINDER
R
PILOT VALVE
TRAVEL
ARM
SWING
BOOM
BUCKET
T
P
P
T
P
P
T
T
SWIVEL JOINT
FRONT RIGHT
FRONT LEFT
REAR RIGHT
REAR LEFT
F
A
D
E
C
B
SWING MOTOR
PG
SH
Pi
R
ARM
(R) (H)
BUCKET
(H) (R)
P
T
LEVER LOCK
TRAVEL 2-SPEED
F C MODE
A1
A2
A3
A4
SOLENOID VALVE
PB2
PB5
DR
B5
B4
B3
B2
B1
A5
A4
A3
A2
A1
ARM
TRAVEL LEFT
TRAVEL RIGHT
BOOM
BUCKET
PO
P5
PS
PO
PA5
T2
P2
P1
T1
REDUCTION UNIT (TRAVEL)
SPROCKET
RIGHT TRAVEL MOTOR
C2
C1
D
BRAKE VALVE
A
C
E
D
B
F
BRAKE VALVE
LEFT TRAVEL MOTOR
C1
C2
SPROCKET
REDUCTION UNIT (TRAVEL)
HYDRAULIC TANK
DRAIN FILTER
RELIEF VALVE
LINE FILTER
P P
T
OUT
IN
OIL COOLER
RADIATOR
ENGINE
A1
A2
A3
S3
GEAR PUMP
VARIABLE DISPLACEMENT PUMP

Fig. 1B Diagram of Major Hydraulic Circuits

3. HYDRAULIC CIRCUITS AND COMPONENTS APPLICABLE MACHINS : LE-11001~

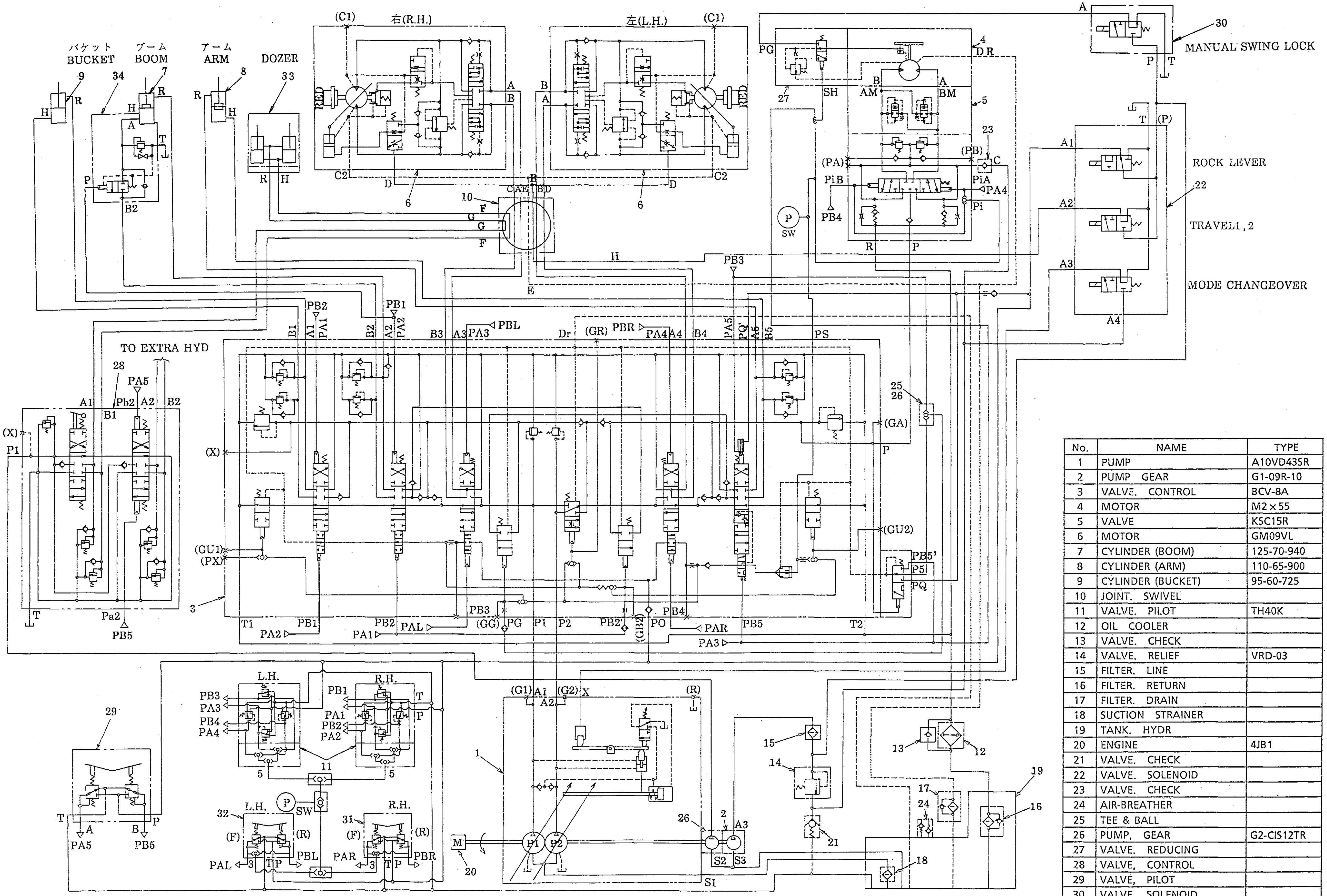

バケット
BUCKET
ブーム
BOOM
アーム
ARM
右(R.H.)
左(L.H.)
(C1)
C2
D
RED
A
B
C
E
F
PG
SH
DR
AM
BM
(PA)
(PB)
PiB
PiA
PA4
Pi
PB4
P
SW
R
T
(P)
A1
A2
A3
A4
ROCK LEVER
TRAVEL1,2
MODE CHANGEOVER
PB1
PB2
PB3
PA1
PA2
B1
B2
B3
B4
B5
A3
A4
A5
A6
PA5
PQ'
Dr
(GR)
PS
(GA)
(X)
(GU1)
(PX)
(GU2)
PB5'
P5
PQ
T1
T2
PM
(GG)
PG
P1
P2
PB2'
(GB2)
PO
PN
PB5
PA3
(G1)
(G2)
X
(R)
M
P1
P2
A3
S1
S3
PA4
PB4
PB3
PA3
PA2
PB2
PB1
PA1
H
R
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

符号	NAME	名　称	型　番
1	PUMP	ポンプ	A10VD43SR
2	PUMP. GEAR	ギヤポンプ	G1-09R-10
3	VALVE. CONTROL	コントロールバルブ	BCV-8A
4	MOTOR	旋回モータ	M2X55
5	VALVE	旋回コントロールバルブ	KSC15R
6	MOTOR	走行モータ	GM09VL
7	CYLINDER(BOOM)	シリンダ(ブーム)	125-70-940
8	CYLINDER(ARM)	シリンダ(アーム)	110-65-900
9	CYLINDER(BUCKET)	シリンダ(バケット)	95-60-725
10	JOINT. SWIVEL	スイベルジョイント	
11	VALVE. PILOT	パイロットバルブ	TH40K
12	OIL COOLER	オイルクーラ	
13	VALVE. CHECK	チェックバルブ	
14	VALVE. RELIEF	リリーフバルブ	VRD-03
15	FILTER. LINE	ラインフィルタ	
16	FILTER RETURN	リタンフィルタ	
17	FILTER. DRAIN	ドレンフィルタ	
18	SUCTION. STRAINER	サクション･ストレーナ	
19	TANK. HYDR	ハイドリック･タンク	
20	ENGINE	エンジン	4JB1
21	VALVE. CHECK	チェックバルブ	
22	VALVE. SOLENOID	ソレノイドバルブ	
23	VALVE. CHECK	チェックバルブ	
24	AIR-BREATHER	エアーブリーザ	
25	TEE	ティー	
26	BALL	ボール	
27	VALVE. REDUCING	レデューシングバルブ	

Fig. 2A

3. HYDRAULIC CIRCUITS AND COMPONENTS

APPLICABLE MACHINS : LE-11001~ (DOZER & EXTRA HYD. SPEC.)



バケット
BUCKET
ブーム
BOOM
アーム
ARM
DOZER
9
34
7
8
33
(C1)
右(R.H.)
左(L.H.)
(C1)
RED
RED
C2
D
6
C2
D
6
10
CAE
BD
F
G
G
F
H
E
PG
27
SH
4
DR
B
A
AM
BM
5
23
(PA)
(PB)
C
PiB
PiA
PA4
Pi
PB4
P
SW
R
P
A
30
MANUAL SWING LOCK
P
T
T
(P)
A1
ROCK LEVER
22
A2
TRAVEL1, 2
A3
MODE CHANGEOVER
A4
PB3
PB2
PB1
B1
A1
PA1
B2
A2
PA2
B3
A3
PA3
PBL
Dr
(GR)
PBR
PA4
A4
B4
PA5
PQ'
A5
B5
PS
TO EXTRA HYD
28
PA5
A1
Pb2
A2
B2
B1
(X)
P1
(X)
T
Pa2
PB5
3
25
26
(GA)
P
(GU2)
(GU1)
(PX)
PB5'
P5
PQ
T1
PB1
PB2
PAL
PB3
(GG)
PG
P1
P2
PB2'
(GB2)
PO
PB4
PAR
PB5
T2
PA2
PA1
PA3
L.H.
R.H.
PB3
PA3
PB4
PA4
PB1
PA1
PB2
PA2
T
P
11
5
5
29
T
A
B
P
PA5
PB5
32
L.H.
P
SW
31
R.H.
(F)
(R)
(F)
(R)
PAL
PBL
PAR
PBR
T
P
T
P
1
(G1)
A1
A2
(G2)
X
(R)
M
20
P1
P2
26
2
A3
S2
S3
S1
15
14
21
13
12
17
24
19
16
18

No.	NAME	TYPE
1	PUMP	A10VD43SR
2	PUMP GEAR	G1-09R-10
3	VALVE. CONTROL	BCV-8A
4	MOTOR	M2×55
5	VALVE	KSC15R
6	MOTOR	GM09VL
7	CYLINDER (BOOM)	125-70-940
8	CYLINDER (ARM)	110-65-900
9	CYLINDER (BUCKET)	95-60-725
10	JOINT. SWIVEL	
11	VALVE. PILOT	TH40K
12	OIL COOLER	
13	VALVE. CHECK	
14	VALVE. RELIEF	VRD-03
15	FILTER. LINE	
16	FILTER. RETURN	
17	FILTER. DRAIN	
18	SUCTION STRAINER	
19	TANK. HYDR	
20	ENGINE	4JB1
21	VALVE. CHECK	
22	VALVE. SOLENOID	
23	VALVE. CHECK	
24	AIR-BREATHER	
25	TEE & BALL	
26	PUMP, GEAR	G2-CIS12TR
27	VALVE. REDUCING	
28	VALVE, CONTROL	
29	VALVE, PILOT	
30	VALVE, SOLENOID	
31	VALVE, PILOT	R.H.
32	VALVE, PILOT	L.H.
33	CYLINDER	80-50-160
34	VALVE. HOLDING	

Fig. 2B

4. FUNCTIONAL DESCRIPTION OF HYDRAULIC CIRCUITS

4.1 NEUTRAL CIRCUIT

(1) Pilot circuit (Provided the lever is unlocked.)

1) Primary pilot pressure circuit

The oil discharged from port A3 of gear pump (2) passes through line filter (15) and relief valve (14) and causes the primary pressure to connect to the following components :

Port P of solenoid valve (22)

Port of pilot valve (11)

Ports P0, PQ' of control valve (3)

Port PQ of the sequence valve

However, since the steering circuit is fully closed, the oil discharged from the gear pump of pump (1) is all relieved by relief valve (14) and returns to the tank by way of check valve (21).

2) Secondary pilot circuit

Because pilot valve (11) is in neutral, the secondary pilot pressure is not built up, but if the operating lever is operated, the secondary pilot pressure from the pilot valve is admitted to the pilot port of the control valve to actuate the spool.

3) Safety device by lever lock

The lever lock device unlocks the lever when the lefthand control stand is tilted forward and locks the lever if the stand is tilted back. If the lever is locked, solenoid valve (22) is changed over, and the primary pilot pressure is cut off by solenoid valve (22) and does not connect with pilot valve (11). For this reason, when operating the lever, tilt the control stand forward to unlock the lever.

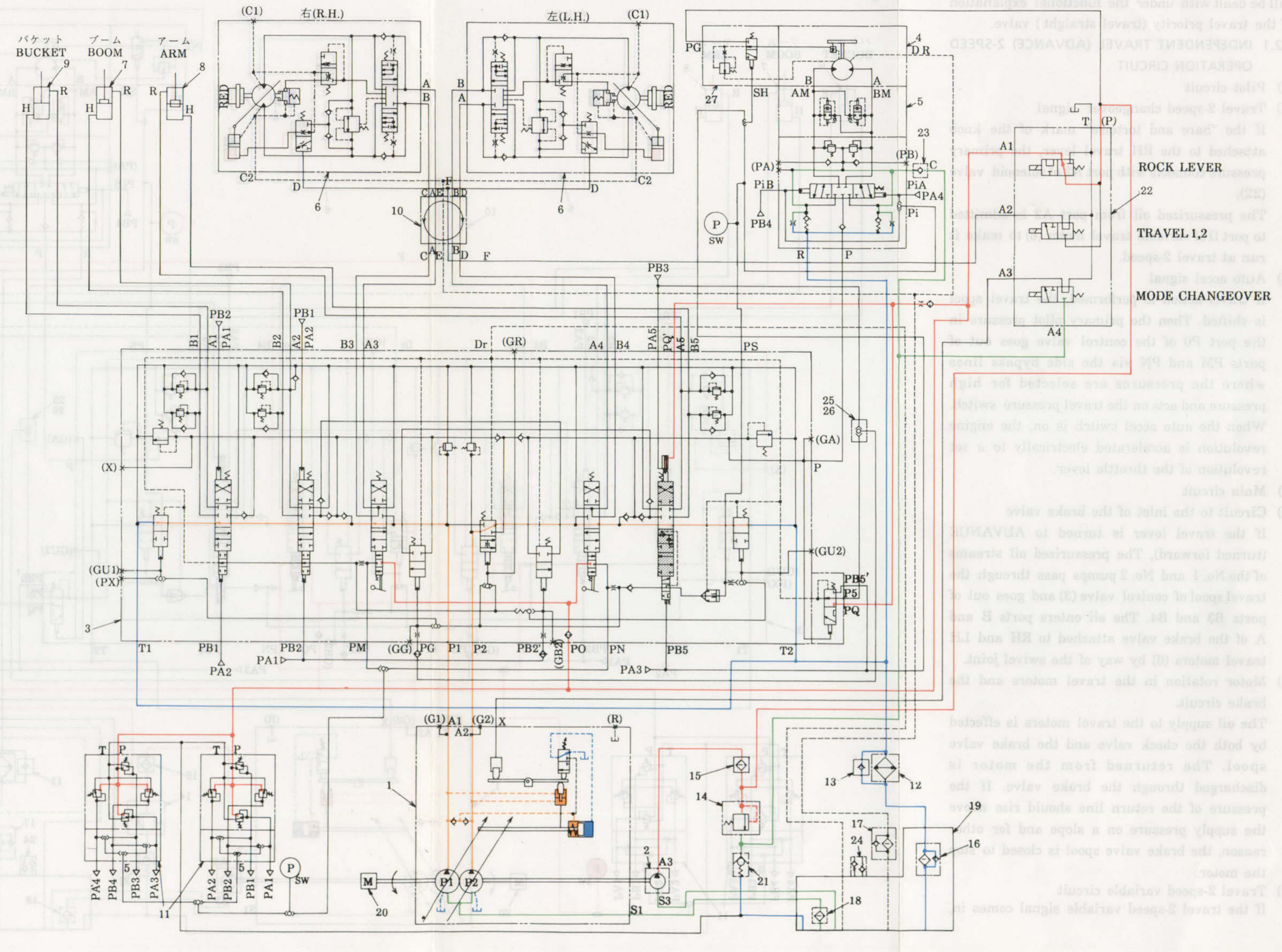
However, travel action is locked mechanically if the control stand is tilted backward.

(2) Main circuit

Oil supply to the main circuit is effected by two variable pumps that suck oil through suction strainer (18) in the tank and introduce high pressure oil to ports P1 and P2 of control valve (3).

The oil that has passed the control valve is discharged from ports T1 and T2.

Returned oil after discharged enters filter element (16) in the tank via the oil cooler where contamination is eliminated from the oil.


バケット
BUCKET
ブーム
BOOM
アーム
ARM
右(R.H.)
左(L.H.)
(C1)
C2
ROCK LEVER
TRAVEL 1,2
MODE CHANGEOVER
PG
SH
AM
BM
D.R.
SW
PiA
PiB
PA4
PB4
B1
A1
PA1
PB1
PB2
B2
A2
PA2
B3
A3
Dr
(GR)
A4
B4
PA5
PQ
A6
B5
PS
(GA)
(X)
(GU1)
(PX)
(GU2)
PB5'
P5
PQ
T1
PM
(GG)
PG
P1
P2
PB2'
(GB)
PO
PN
PB5
PA3
T2
(G1)
(G2)
(R)
P1
P2
S1
S3
M
1
2
3
4
5
6
7
8
9
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22
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25
26
27

Fig. 3 Neutral circuit (in the H mode)

4.2 TRAVEL CIRCUIT

The travel circuit is featured by travel straight, travel boost pressure and 2-speed travel. Steering is effected by a control cable.

Functional explanation of travel straight action will be dealt with under the functional explanation of the travel priority (travel straight) valve.

4.2.1 INDEPENDENT TRAVEL (ADVANCE) 2-SPEED OPERATION CIRCUIT

(1) Pilot circuit

1) Travel 2-speed changeover signal

If the "hare and tortoise" mark of the knob attached to the RH travel lever, the primary pressure connects with port A2 of solenoid valve (22).

The pressurized oil from port A2 is admitted to port D of variable travel motor (6) to make it run at travel 2-speed.

2) Auto accel signal

If travel action is performed, the travel spool is shifted. Then the primary pilot pressure in the port P0 of the control valve goes out of ports PM and PN via the side bypass lines where the pressures are selected for high pressure and acts on the travel pressure switch. When the auto accel switch is on, the engine revolution is accelerated electrically to a set revolution of the throttle lever.

(2) Main circuit

1) Circuit to the inlet of the brake valve

If the travel lever is turned to ADVANCE (turned forward), The pressurized oil streams of the No. 1 and No. 2 pumps pass through the travel spool of control valve (3) and goes out of ports B3 and B4. The oil enters ports B and A of the brake valve attached to RH and LH travel motors (6) by way of the swivel joint.

2) Motor rotation in the travel motors and the brake circuit.

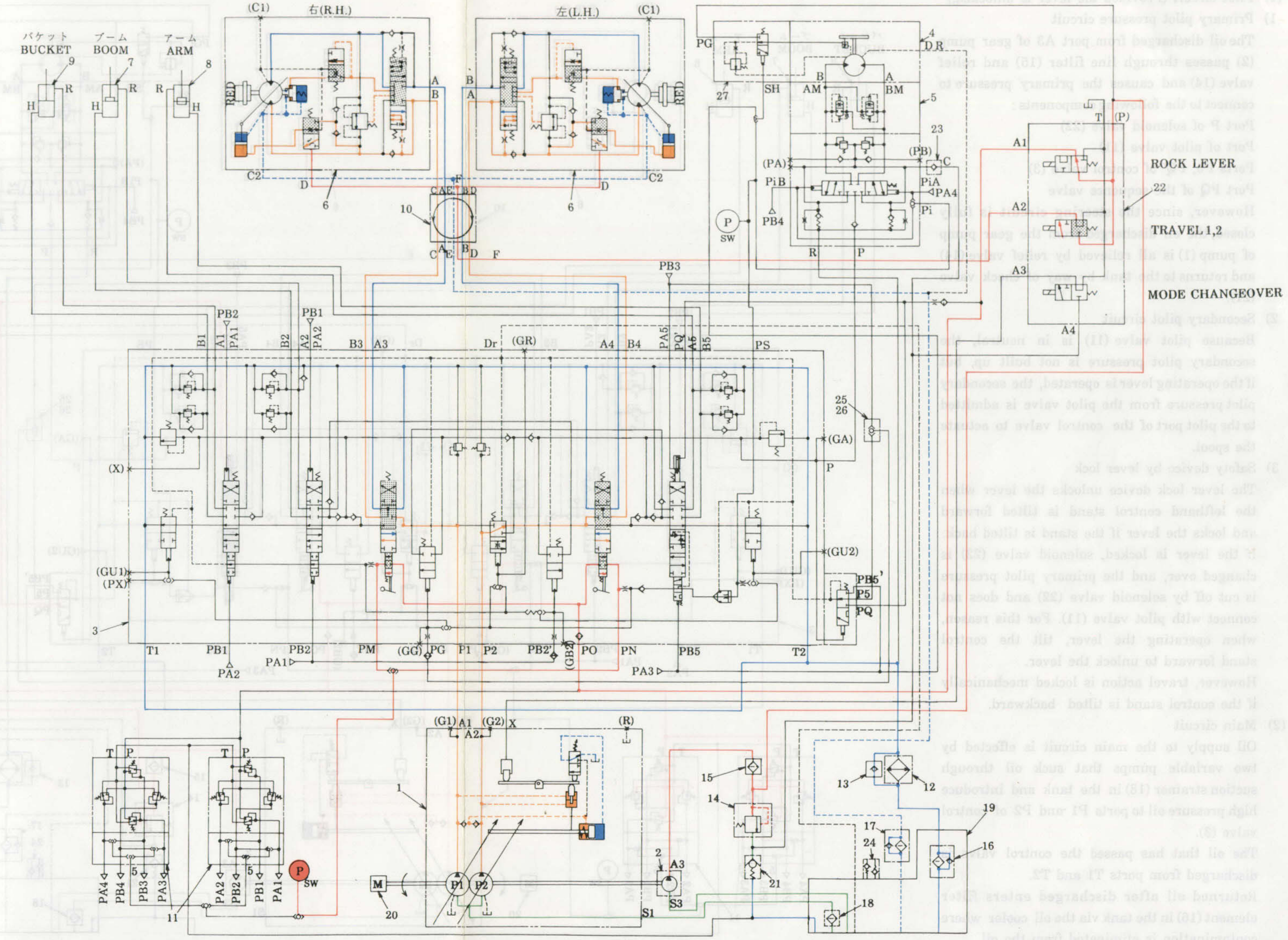
The oil supply to the travel motors is effected by both the check valve and the brake valve spool. The returned from the motor is discharged through the brake valve. If the pressure of the return line should rise above the supply pressure on a slope and for other reason, the brake valve spool is closed to stop the motor.

3) Travel 2-speed variable circuit

If the travel 2-speed variable signal comes in, the main circuit pressure increases the inclination of the swash plate of the motor to step up the motor revolution.

4) Travel boost pressure circuit

The pressure travel relief valve (602) is set higher than that of main relief valve (601).



バケット BUCKET
ブーム BOOM
アーム ARM
9
7
8
H
R
(C1)
右(R.H.)
左(L.H.)
RED
A
B
C2
D
6
C A E B D
F
10
PG
4
DR
SH
AM
BM
5
27
23
(PB)
C
(PA)
PiB
PiA
PA4
Pi
PB4
P
SW
R
P
A1
ROCK LEVER
22
A2
TRAVEL 1,2
A3
MODE CHANGEOVER
A4
T
(P)
PB3
PB2
PB1
B1
A1
PA1
B2
A2
PA2
B3
A3
Dr
(GR)
A4
B4
PA5
PO
A5
B5
PS
25
26
(GA)
(X)
(GU1)
(PX)
(GU2)
PB5'
P5
PQ
3
T1
PB1
PA2
PB2
PA1
PM
(GG)
PG
P1
P2
PB2'
(GB)
PO
PN
PB5
PA3
T2
(G1)
A1
A2
(G2)
X
(R)
T
P
PA4
PB4
PB3
PA3
PA2
PB2
PB1
PA1
5
11
1
P
SW
M
20
P1
P2
2
A3
S3
S1
15
14
13
12
19
17
24
16
21
18

Fig. 4 Simple Travel in 2nd speed (forward)

4.2.2 FUNCTIONAL EXPLANATION OF TRAVEL PRIORITY (TRAVEL STRAIGHT) VALVE

In a combined operation of the attachment and the swing motions, travel priority changeover valve (61) is switched over. The valve is switched over by pilot pressure. Hereinunder is described how the travel priority changeover is performed by pilot pressure.

1) When the travel operation lever is in neutral: See Fig. 5. The pilot pressure flows from gear pump (P3) to port (P0) of the control valve as servo pressure. When the operating lever is in neutral, the servo pressure passes through both orifices, but does not run downstream as it is cut off by the lever.

2) At independent travel operation
See Fig. 6. Next, when the travel spool moves, the path to the lower stream is opened. The oil either runs to the drain line or pushes logic valve (80) to be lead to the drain line. In either way, pressure that switches travel priority valve (61) over is not built up.

3) Combined operation of travel action and the downstream spool (arm, boom, bucket or swing)
See Fig. 7. Since the downstream spool cuts off the return path to the tank (In the case of swing action, however, the secondary pilot pressure which has passed through logic valve (80) pushes check valve (64) from behind.), the pilot pressure rises and changes valve (61) over and at the same time switches neutral cut valves (72) (77) over.

56	Swing pilot circuit	72	Neutral cut valve
60	Servo pressure circuit	77	Neutral cut valve
61	Travel priority changeover valve	80	Logic valve
64	Check valve		

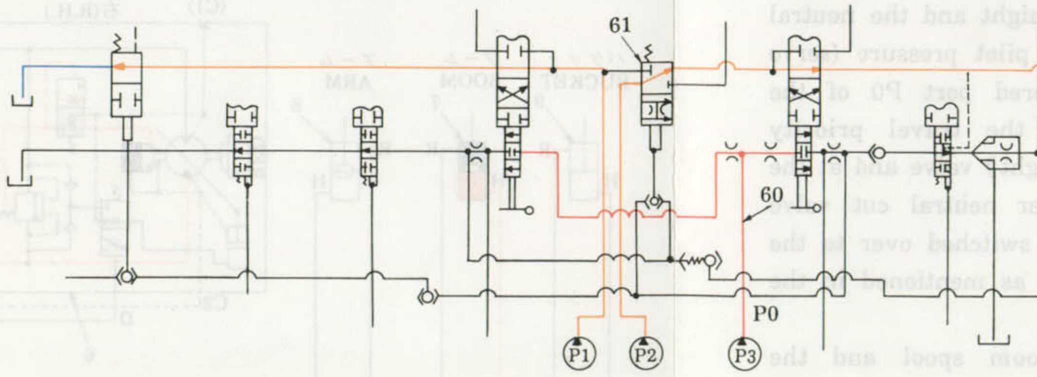

61
60
P0
P1
P2
P3

Fig. 5 At neutral

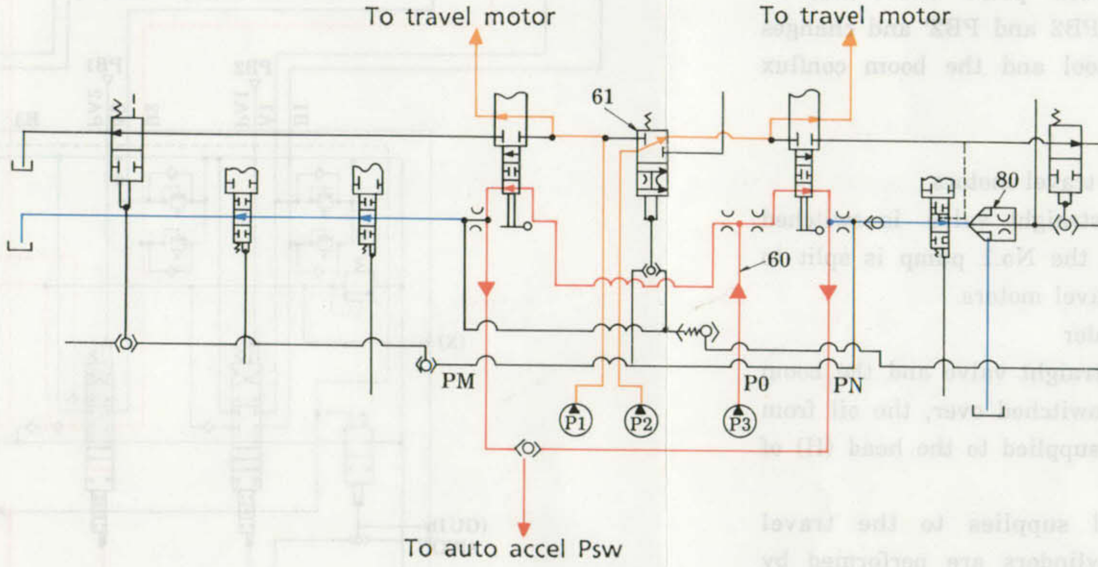

To travel motor
To travel motor
61
80
60
PM
P0
PN
P1
P2
P3
To auto accel Psw

Fig. 6 During Simple Travel

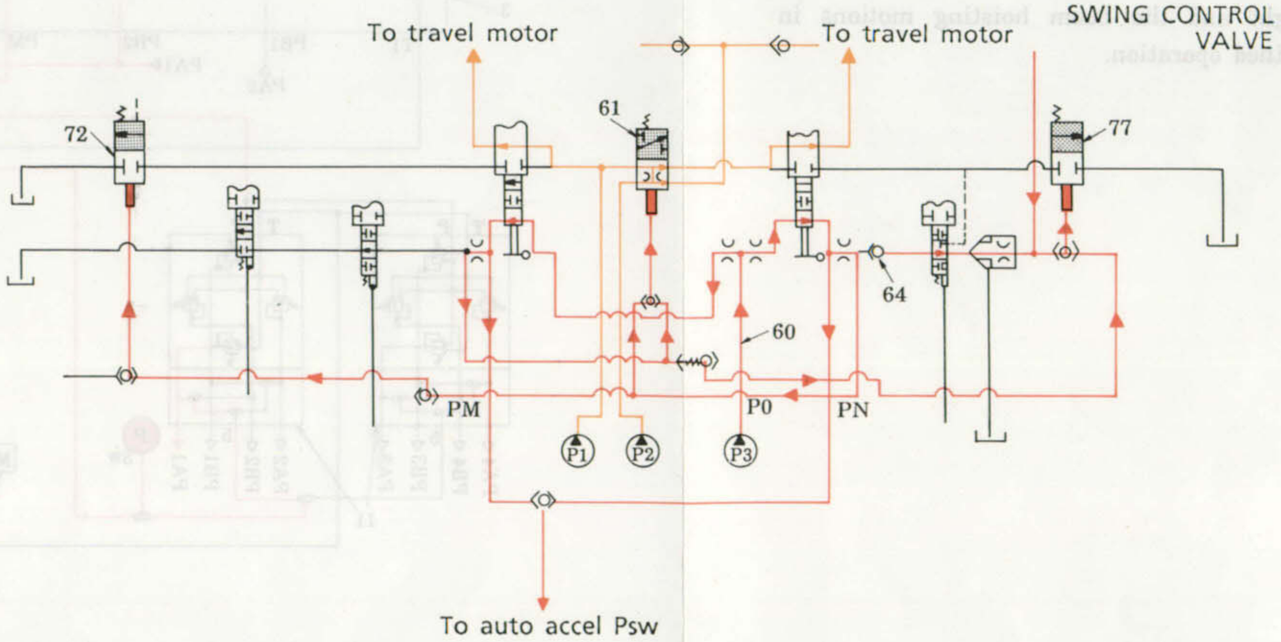

To travel motor
To travel motor
SWING CONTROL VALVE
72
61
77
64
60
PM
P0
PN
P1
P2
P3
To auto accel Psw

Fig. 7 At combined operation of the attachment and swing motions

4.2.3 TRAVEL 1-SPEED(ADVANCE) / BOOM HOISTING CIRCUIT

(1) Pilot circuit

1) When the primary pilot pressure shifts the spools of the travel straight and the neutral cut valve, the primary pilot pressure (servo circuit) that has entered port P0 of the control valve changes the travel priority changeover (travel straight) valve and at the same time changes over neutral cut valve (77) when the mode is switched over to the travel priority function, as mentioned in the foregoing page.

2) Changing over the boom spool and the conflux valve by the secondary pilot pressure. If boom hoisting action is done, the secondary pilot pressure from pilot valve (11) is admitted to ports PB2 and PB2' and changes over the boom spool and the boom conflux valve.

(2) Main circuit

1) Oil supply to both travel motors

When the travel straight valve is switched over, the oil from the No.1 pump is split to the RH and LH travel motors.

2) Oil supply to cylinder

When the travel straight valve and the boom conflux valve are switched over, the oil from the No.2 pump is supplied to the head (H) of the boom cylinder.

Therefore, the oil supplies to the travel motors and the cylinders are performed by separate pumps in order to execute the travel straight and the boom hoisting motions in combined operation.

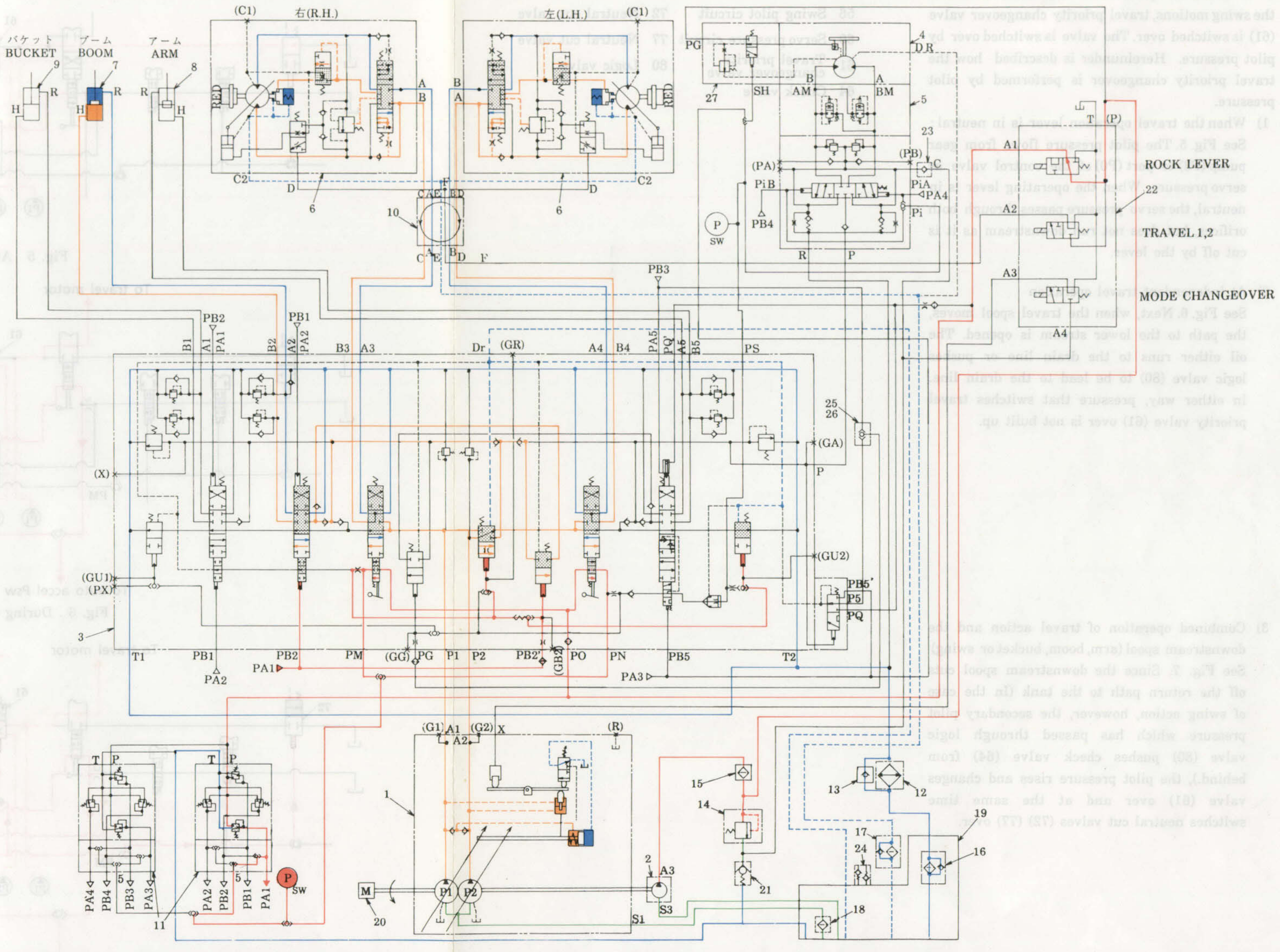

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Fig. 8 Travel 1-speed (advance) / boom hoisting (travel straight) circuits

4.3 SWING CIRCUIT

The swing circuit is featured by an independent swing control valve to promote the controllability of the swing action.

4.3.1 INDEPENDENT SWING ACTION

(1) Pilot circuit

1) Changing over the spool of the swing control valve

If swing action is performed, the secondary pilot pressure (PA4 or PB4) from pilot valve (11) enters port PiA or PiB of the swing control valve and changes over the spool of the swing control valve.

2) Releasing the auto swing parking brake

The pressurized oil from port Pi of the swing control valve enters port SH of reducing valve (27), opens the circuit of the swing parking brake. The primary pressure from the PG port releases the brake.

3) Lighting the swing flasher lamp

The pilot pressure from port Pi, mentioned above, acts on the pressure switch, turning on the swing flasher lamp.

4) Changing over the neutral cut valve and closing the check valve

The above - mentioned pilot pressure from the Pi port enters port PS of the control valve. It then changes over the neutral cut valve and check valve (64).

5) Swing - back prevention function of swing shockless valve

The swing - back prevention valve in the swing control valve prevents swing - back motion that may otherwise occur when swing motion is suspended.

6) Delayed braking by the reducing valve

In order to prevent the swing parking brake from acting when swing inertia is present, the oil returing from the swing parking brake cylinder returns to the drain line by way of delay valve (27).

(2) Main circuit

1) Oil supply circuit for the swing motor

If swing action is performed, the pressurized oil from the No.2 pump goes out of port P of main control valve (3) and enters port P of swing control valve (6) to drive the swing motor.

2) Return circuit from the swing motor

The oil returning from port T of the swing control valve returns directly to the hydraulic tank past the oil cooler, instead of passing through the main control valve.

3) Drain circuit

The drain from the swing motor is brought back to the hydraulic tank via the drain filter (17).

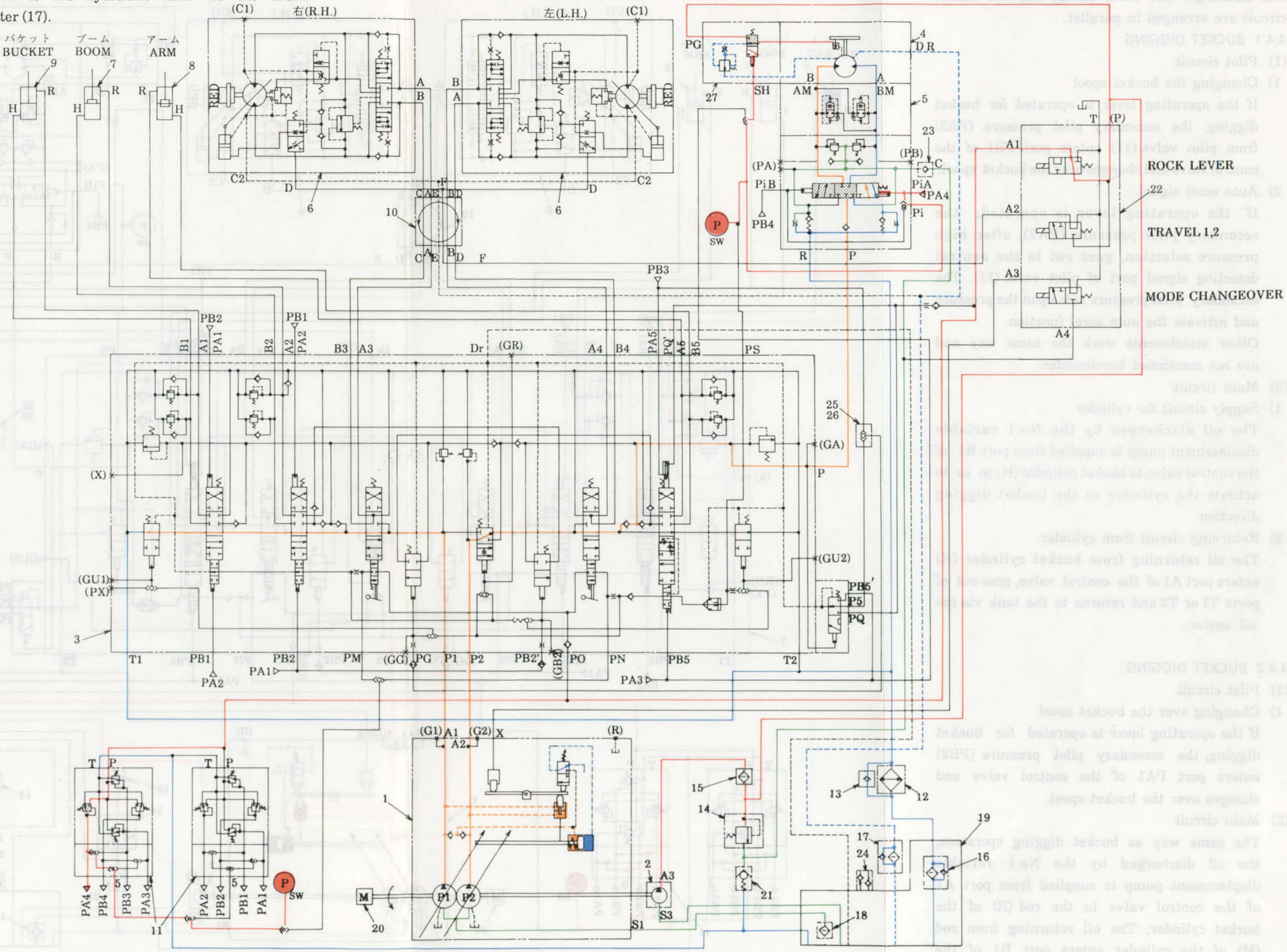
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Fig. 9 Auto accel operation circuit for independent swing (left swing) action

4.4 BUCKET CIRCUIT

The circuit is featured by the No.1 variable displacement pump that performs bucket digging and discharge. The boom circuit and the bucket circuit are arranged in parallel.

4.4.1 BUCKET DIGGING

(1) Pilot circuit

1) Changing the bucket spool

If the operating lever is operated for bucket digging, the secondary pilot pressure (PA2) from pilot valve (11) enters port PB1 of the control valve and changes over the bucket spool.

2) Auto accel signal

If the operating lever is operated, the secondary pilot pressure (PA2), after high pressure selection, goes out to the neutral detecting signal port of pilot valve (11). The secondary pilot pressure acts upon the pressure and activate the auto accel function.

Other attachments work the same way and are not mentioned hereinunder.

(2) Main circuit

1) Supply circuit for cylinder

The oil discharged by the No.1 variable displacement pump is supplied from port B1 of the control valve to bucket cylinder (H) so as to actuate the cylinder in the bucket digging direction.

2) Returning circuit from cylinder

The oil returning from bucket cylinder (R) enters port A1 of the control valve, goes out of ports T1 or T2 and returns to the tank via the oil cooler.

4.4.2 BUCKET DIGGING

(1) Pilot circuit

1) Changing over the bucket spool

If the operating lever is operated for bucket digging, the secondary pilot pressure (PB2) enters port PA1 of the control valve and changes over the bucket spool.

(2) Main circuit

The same way as bucket digging operation, the oil discharged by the No.1 variable displacement pump is supplied from port A1 of the control valve to the rod (R) of the bucket cylinder. The oil returning from rod (H) of the cylinder enters port B1 of the control valve and returns to the hydraulic tank through ports T1 or T2.

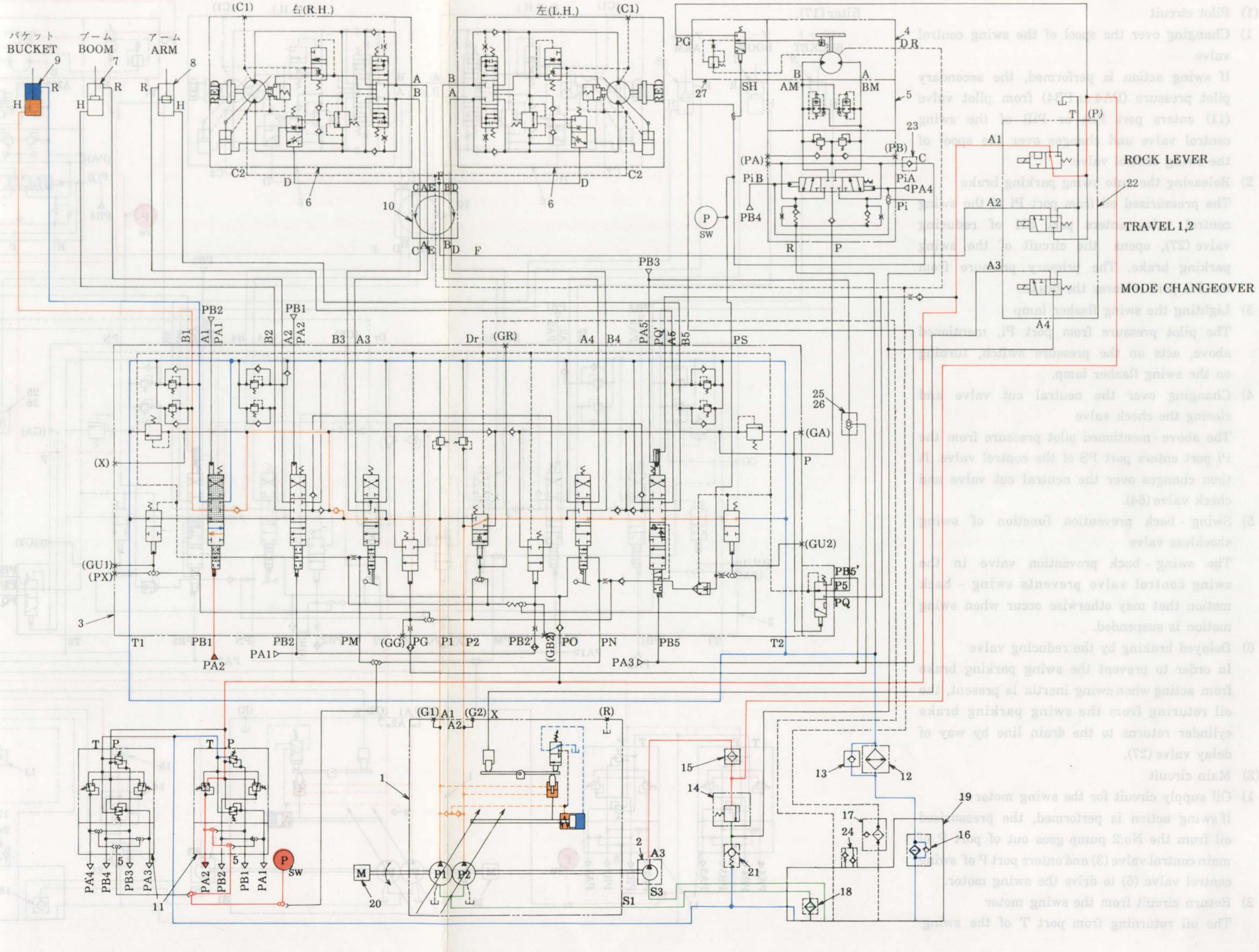

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Fig. 10 Bucket digging operation

4.5 BOOM CIRCUIT

4.5.1 BOOM RAISING INNER CONFLUX CIRCUIT

The circuit is featured by the oil discharged by two variable displacement pumps combined in the control valve and supplied to the head (H) of the boom cylinder.

(1) Pilot circuit

1) Changing over the boom spool

If the operating lever is brought to boom raising, the secondary pilot pressure (PA1) from the pilot valve enters port PB2 of the control valve and transfers the boom spool.

2) Changing over the boom conflux valve and the neutral cut valve

If boom raising action is performed, the secondary pilot pressure (PA1) from the pilot valve is branched off and enters port PB2' of the control valve to switch over the boom conflux valve (78) and the neutral cut valve (77).

(2) Main circuit

1) Supply circuit for boom cylinder

For boom hoisting action, the oil streams discharged by the No.1 and No.2 variable displacement pumps are combined in the control valve and supplied to the head (H) of the boom cylinder head via port (B2).

2) Returning circuit from cylinder

The oil returning from the rod (R) of the boom cylinder enters port A2 of the control valve, goes out of port T1 or T2 and returns to the tank by way of the oil cooler and the return filter.

Port signals of main circuit

		PUMP	CONTROL VALVE (3)	CYLINDER
BOOM RAISING	Supply	P1 P2	P1 P2 — B2	H
	RETURN	—	T1 T2 — A2	R

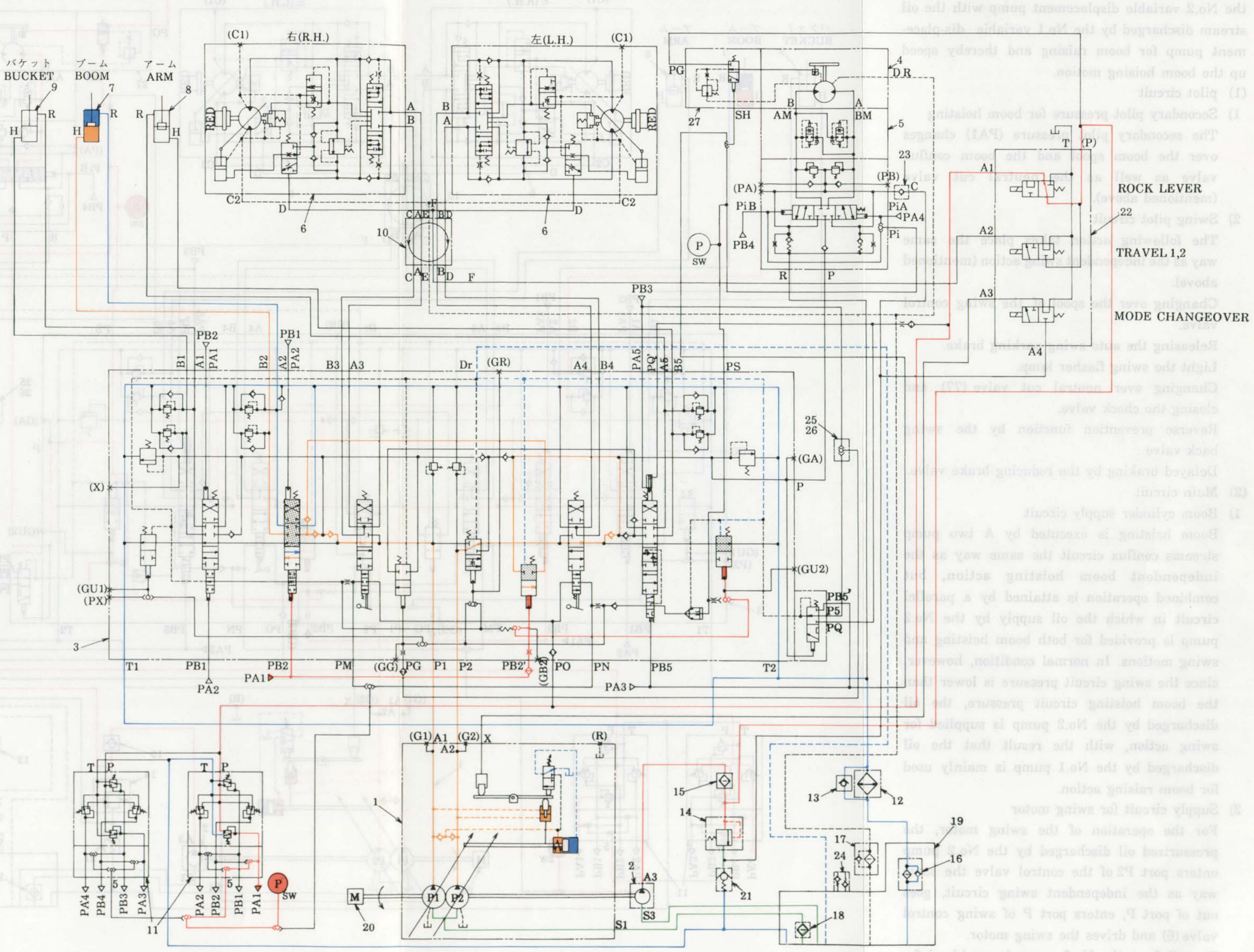

Fig. 11 Boom raising circuit (conflux of two pump oil streams)

4.5.2 COMBINED OPERATION CIRCUIT OF BOOM RAISING AND SWING MOTIONS

The circuit is featured by the boom raising circuit and the swing motor circuit arranged in parallel so as to combine the oil discharged by the No.2 variable displacement pump with the oil stream discharged by the No.1 variable dis-placement pump for boom raising and thereby speed up the boom hoising motion.

(1) pilot circuit

1) Secondary pilot pressure for boom hoisting

The secondary pilot pressure (PA1) changes over the boom spool and the boom conflux valve as well as the neutral cut valve (mentioned above).

2) Swing pilot circuit

The following action takes place the same way as the independent swing action (mentioned above).

Changing over the spool of the swing control valve.

Releasing the auto swing parking brake.

Light the swing flasher lamp.

Changing over neutral cut valve (77) and closing the check valve.

Reverse prevention function by the swing back valve .

Delayed braking by the reducing brake valve.

(2) Main circuit

1) Boom cylinder supply circuit

Boom hoisting is executed by A two pump streams conflux circuit the same way as the independent boom hoisting action, but combined operation is attained by a parallel circuit in which the oil supply by the No.2 pump is provided for both boom hoisting and swing motions. In normal condition, however, since the swing circuit pressure is lower than the boom hoisting circuit pressure, the oil discharged by the No.2 pump is supplied for swing action, with the result that the oil discharged by the No.1 pump is mainly used for boom raising action.

2) Supply circuit for swing motor

For the operation of the swing motor, the pressurized oil discharged by the No.2 pump enters port P2 of the control valve the same way as the independent swing circuit, goes out of port P, enters port P of swing control valve (6) and drives the swing motor.

The oil from the No.2 pump is combined for boom raising motion, but is supplied to the swing motor in normal condition as the swing circuit pressure is low.

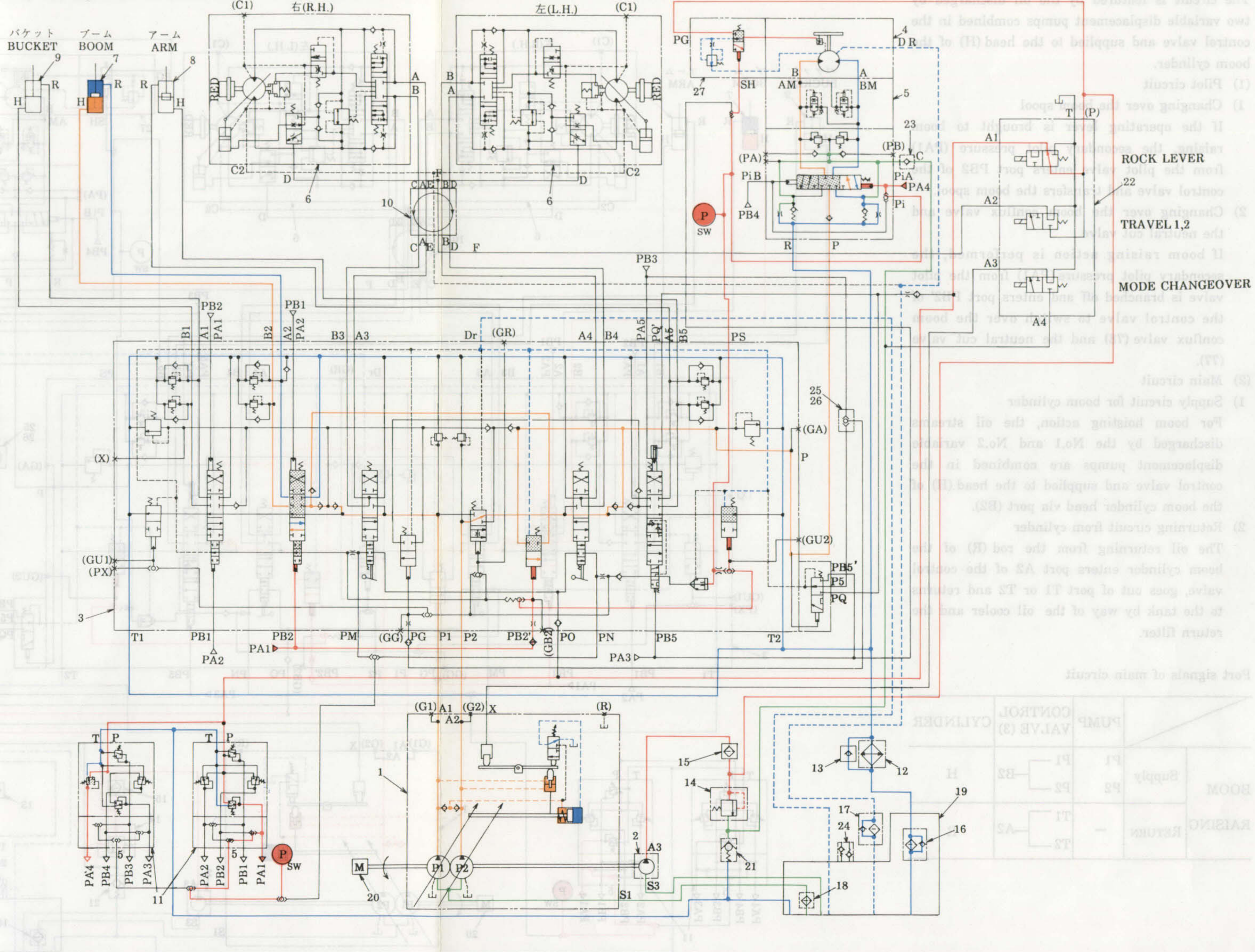

Fig. 12 Boom raising/swing (left) operation circuit

4.5.3 BOOM LOWERING CIRCUIT

The circuit is featured by the fact that boom lowering action is performed by the No.1 variable displacement pump alone.

(1) Pilot circuit

1) Changing over the boom spool

If the operating lever is operated for boom lowering, the secondary pilot pressure (PB1) from the pilot valve enters port PA2 of the control valve and transfers the boom spool.

2) Maximum flow cut

If the operation mode switch is turned to the FC mode, solenoid valve (22) is switched over electrically. As the result, the primary pilot pressure from port A3 enters port X of the pump regulator and performs the maximum flow cut action that reduces the delivery of the variable displacement pump.

(2) Main circuit

1) Supply circuit for cylinder

Boom lowering action is performed by the No.1 variable displacement pump. The pressurized oil delivered by the pump enters port P1 of the control valve, goes out of port A2 and is supplied to the rod (R) of the boom cylinder.

2) Return circuit from cylinder

The oil returning from the head (H) of the boom cylinder returns to port B2 of the control valve and then returns to the tank past port T1 or T2, the cooler and the return filter, in that order.

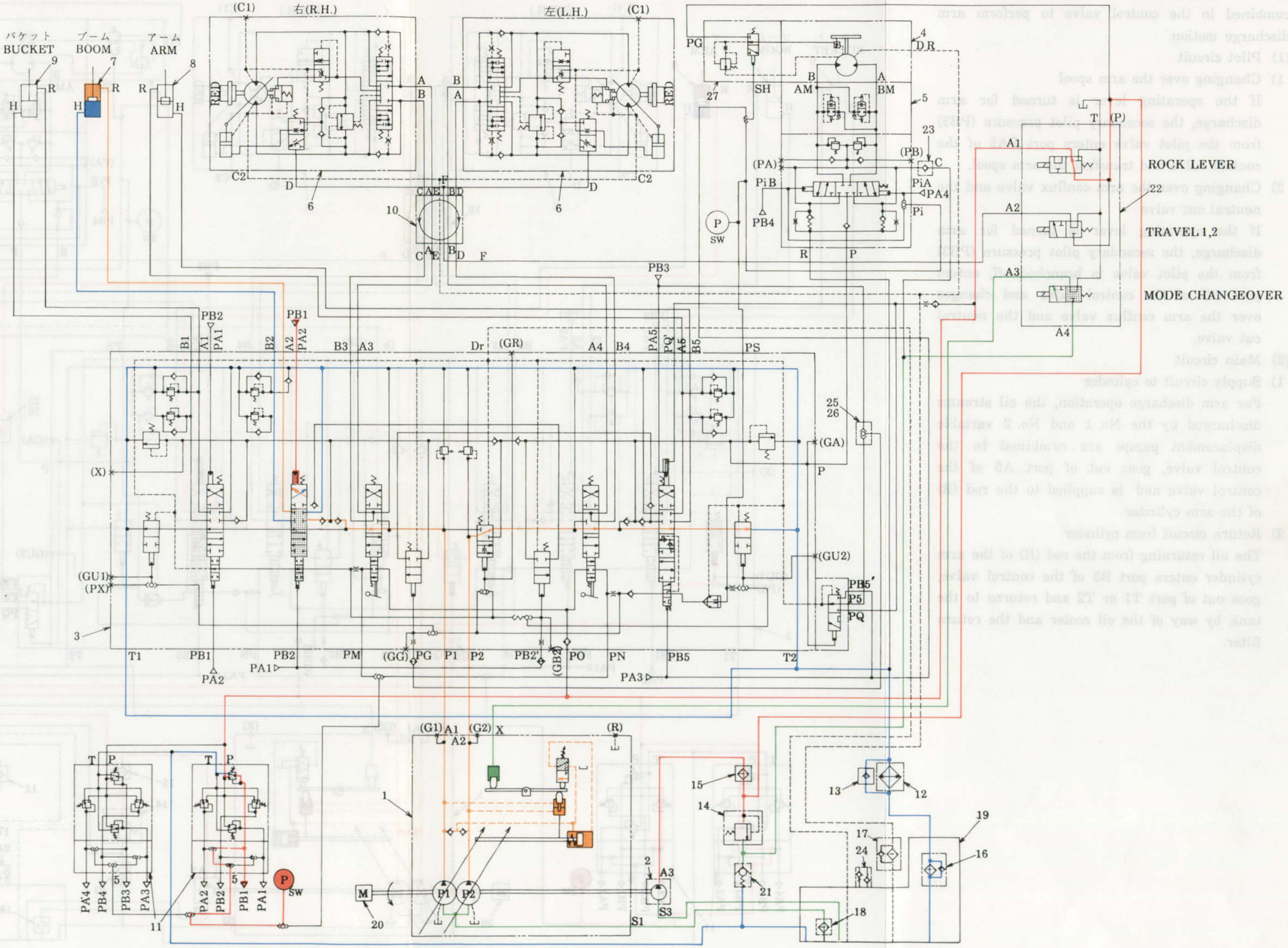
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Fig. 13 Boom lowering (in the S mode) operation circuit

4.6 ARM CIRCUIT

4.6.1 ARM EXTEND INNER CONFLUX CIRCUIT

The circuit is featured by oil streams delivered by two variable displacement pumps that are combined in the control valve to perform arm discharge motion.

(1) Pilot circuit

1) Changing over the arm spool

If the operating lever is turned for arm discharge, the secondary pilot pressure (PB3) from the pilot valve enters port PA5 of the control valve and transfers the arm spool.

2) Changing over the arm conflux valve and the neutral cut valve

If the operating lever is turned for arm discharge, the secondary pilot pressure (PB3) from the pilot valve is branched off, enters port PG of the control valve and changes over the arm conflux valve and the neutral cut valve.

(2) Main circuit

1) Supply circuit to cylinder

For arm discharge operation, the oil streams discharged by the No. 1 and No. 2 variable displacement pumps are combined in the control valve, goes out of port A5 of the control valve and is supplied to the rod (R) of the arm cylinder.

2) Return circuit from cylinder

The oil returning from the rod (R) of the arm cylinder enters port B5 of the control valve, goes out of port T1 or T2 and returns to the tank by way of the oil cooler and the return filter.

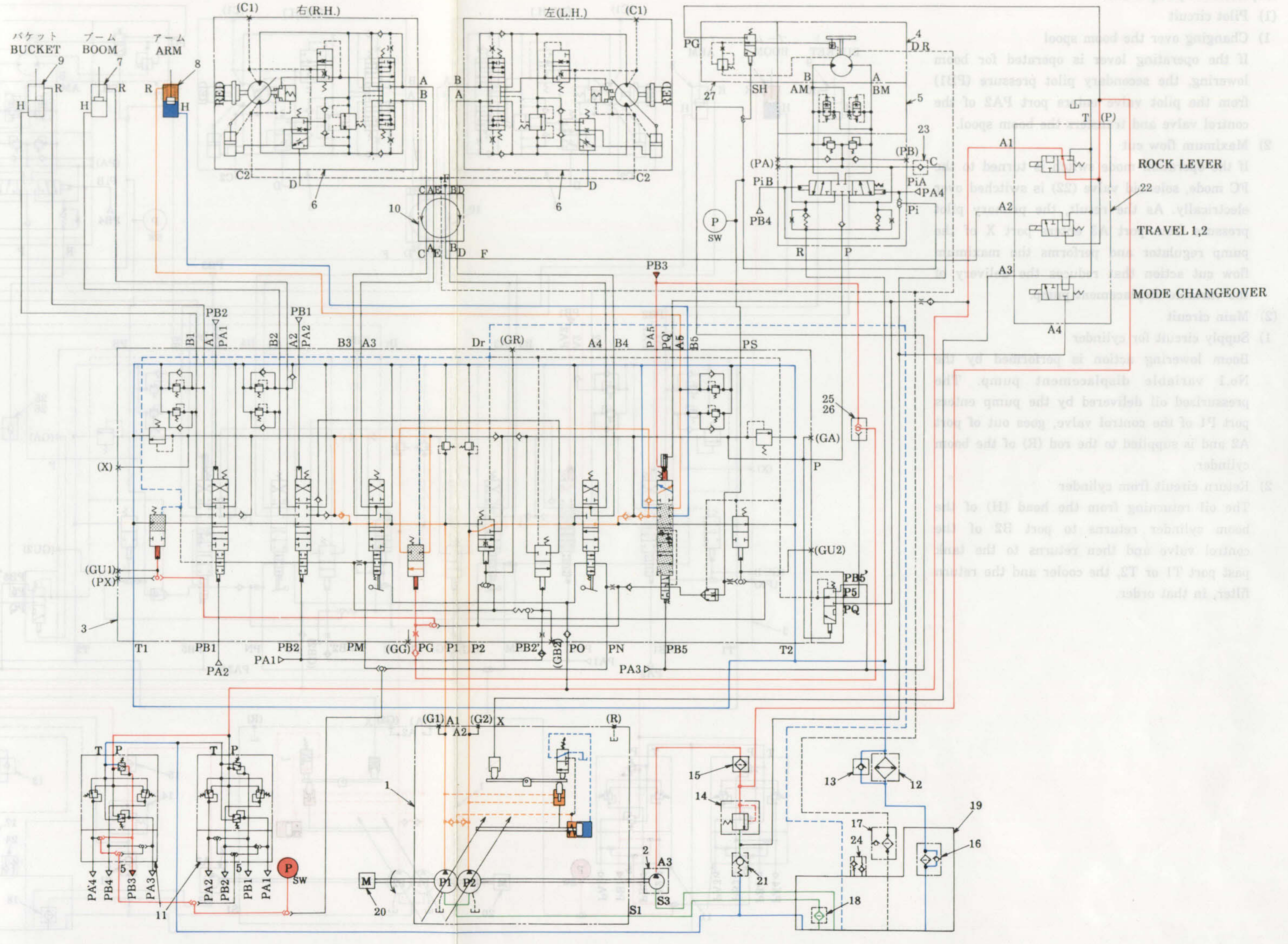

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Fig. 14 Arm extend operation circuit (two pump streams combined)

4.6.2 ARM DIGGING CIRCUIT (FIXED RECYCLING AT LIGHT LOAD)

The circuit is featured by a single variable displacement pump operated at light load and the oil returned from the rod of the arm cylinder that is recycled to the head (H) of the arm cylinder at fixed rate, in order to increase the speed and the speed variation at light load arm digging, thereby preventing cavitation. This fixed recycle circuit works only for light duty arm digging.

(1) Pilot circuit

1) Changing over the arm spool

If the operating lever is turned to arm digging, the secondary pilot pressure (PA3) from the pilot valve enters port PB5 of the control valve and shifts the arm spool.

2) Regulating the transfer of the arm spool

Since the primary pilot pressure enters port PQ' of the arm spool past A1 of solenoid valve (11), the stroke of the arm spool is restricted at arm digging operation to hold the spool at the fixed recycle circuit position.

(2) Main circuit

1) Supply circuit to cylinder

For light-duty arm digging, the oil delivered by the No. 2 variable displacement pump enters port P2 of the control valve, goes out of port B5 and enters the head (H) of the cylinder to perform arm digging operation.

2) Return circuit from cylinder

The oil returned from the rod (R) of the arm cylinder enters port A5 of the control valve and returns to the tank side past fixed restrictor (A) in the arm spool, so that the return circuit pressure rises. Since digging is performed at light load and the supply pressure is not high, the returned oil pushes check valve (B) open and is used for recycling to the feed side. This is called fixed recycle circuit.

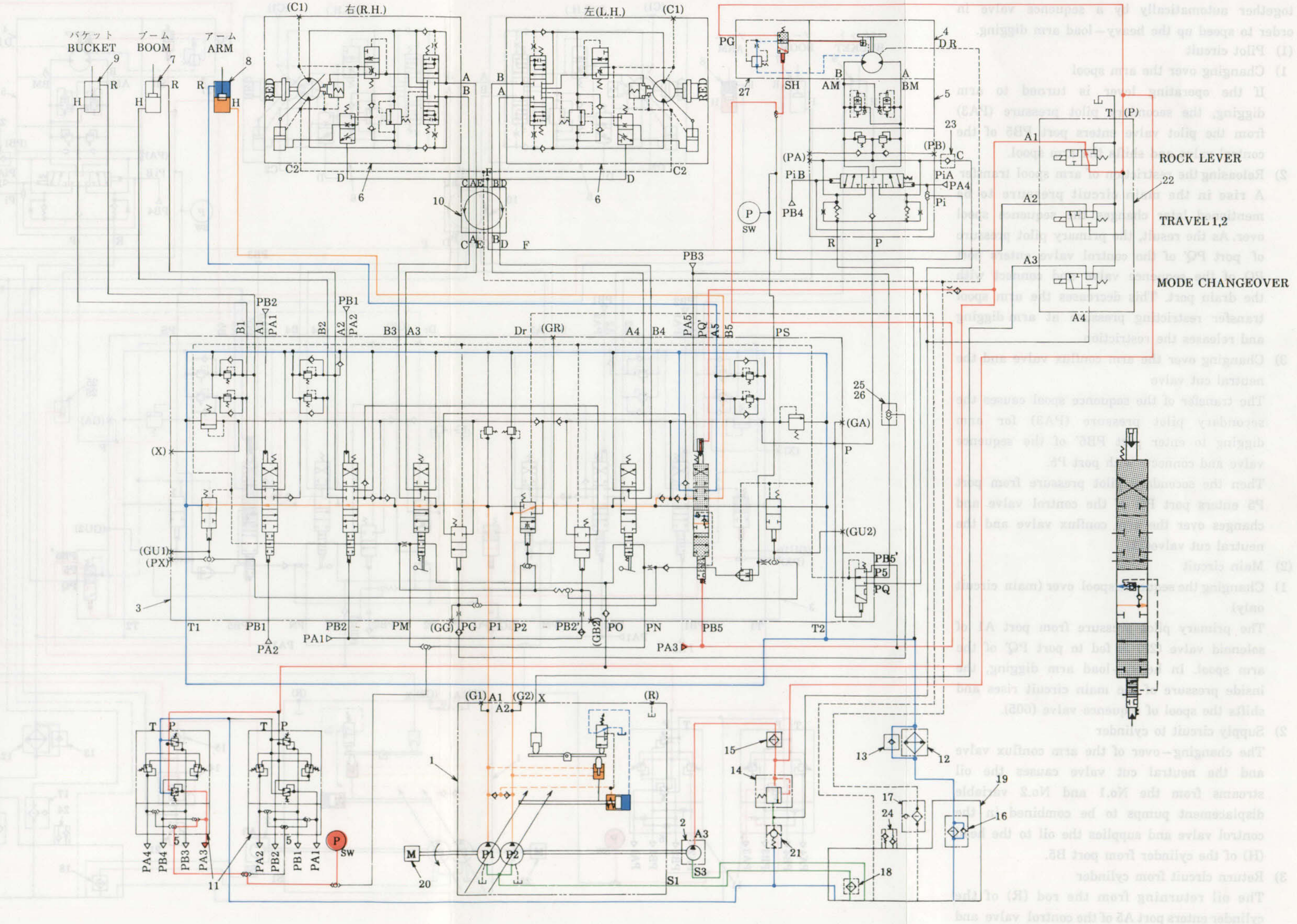
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Fig. 15 Arm digging (fixed recycling at light load) operation circuit

4.6.3 ARM DIGGING (SEQUENCE CONFLUX AT HEAVY LOAD) CIRCUIT

The circuit is featured by an automatic conflux circuit that combines oil streams by two pumps together automatically by a sequence valve in order to speed up the heavy-load arm digging.

(1) Pilot circuit

1) Changing over the arm spool

If the operating lever is turned to arm digging, the secondary pilot pressure (PA3) from the pilot valve enters port PB5 of the control valve and shifts the arm spool.

2) Releasing the restriction of arm spool transfer

A rise in the main circuit pressure to be mentioned later changes the sequence spool over. As the result, the primary pilot pressure of port PQ' of the control valve enters port PQ of the sequence valve and connect with the drain port. This decreases the arm spool transfer restricting pressure at arm digging and releases the restriction.

3) Changing over the arm conflux valve and the neutral cut valve

The transfer of the sequence spool causes the secondary pilot pressure (PA3) for arm digging to enter port PB5' of the sequence valve and connects with port P5.

Then the secondary pilot pressure from port P5 enters port PG of the control valve and changes over the arm conflux valve and the neutral cut valve(72).

(2) Main circuit

1) Changing the sequence spool over (main circuit only)

The primary pilot pressure from port A1 of solenoid valve (22) is fed to port PQ' of the arm spool. In heavy-load arm digging, the inside pressure of the main circuit rises and shifts the spool of sequence valve (605).

2) Supply circuit to cylinder

The changing-over of the arm conflux valve and the neutral cut valve causes the oil streams from the No.1 and No.2 variable displacement pumps to be combined in the control valve and supplies the oil to the head (H) of the cylinder from port B5.

3) Return circuit from cylinder

The oil returning from the rod (R) of the cylinder enters port A5 of the control valve and returned to the tank without being recycled.

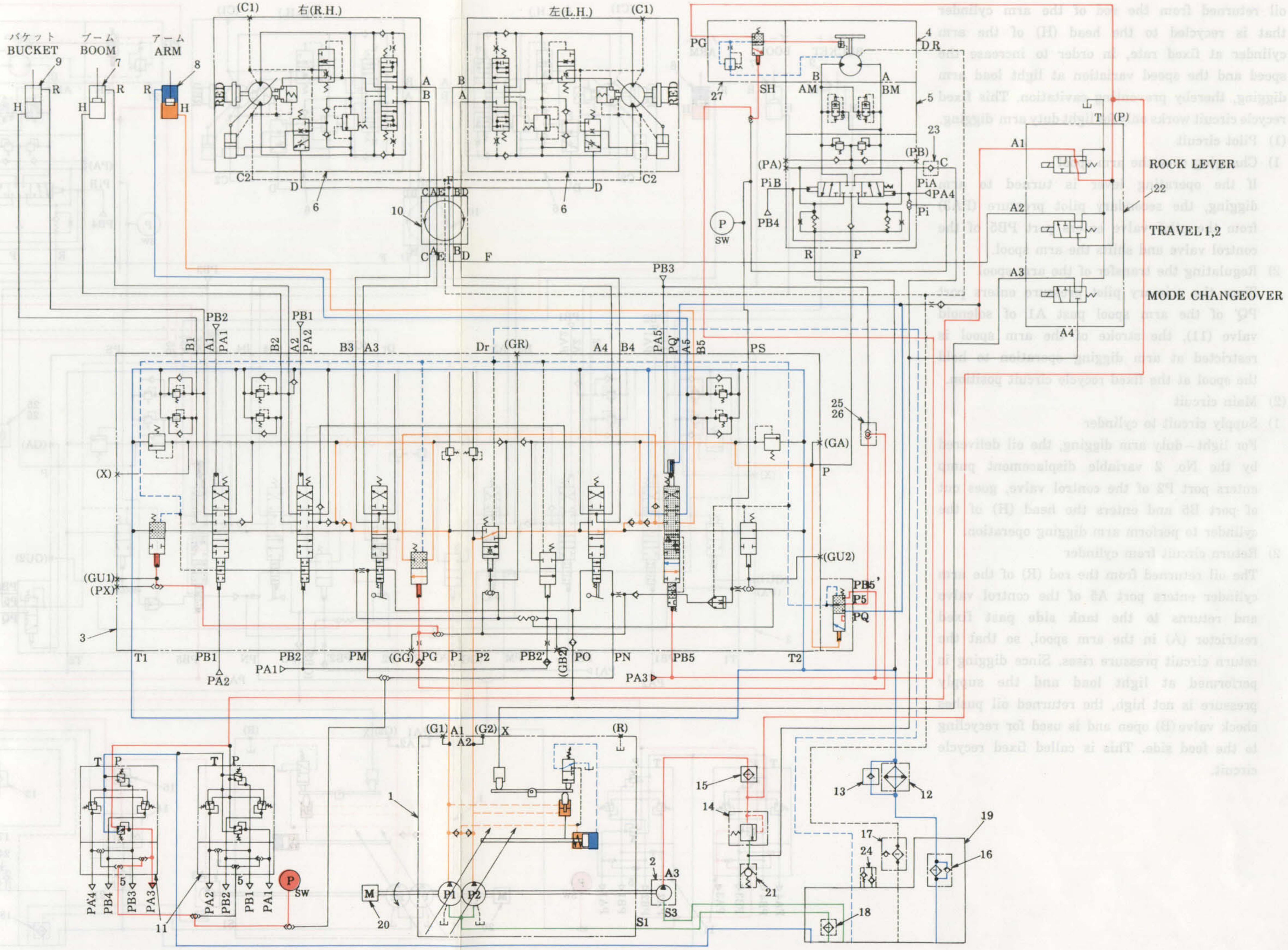
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Fig. 16 Arm digging (heavy load sequence conflux) operation circuit

4.6.4 ARM DIGGING/SWING (SWING PRIORITY) OPERATION CIRCUIT

The circuit is featured by selection of the lighter load between the arm digging and the swing circuits when both circuits work at the same time as oil is supplied from the same pump and the circuits are arranged in parallel in the control valve. For this purpose, a swing priority circuit is employed so as to stabilize the operation speed smooth the pressed swing digging and the oblique arm tugging.

(1) Pilot circuit

1) Changing the arm spool over

In light–duty operation, such as, surface smoothing in a combine operation of arm digging and swing action, the secondary pilot pressure (PA3) for arm tugging enters port PB5 of the control valve and holds the arm spool in the fixed recycle circuit position. (mentioned above)

2) Changing the neutral cut valve over

If swing operation is performed, the secondary pilot pressure (PA4 or PB4) is selected for high pressure, enters port PS of the control valve and changes the neutral cut valve over.

3) Pressing check valve (C)

The secondary pilot pressure for swing motion which has entered port PS of the control valve passes through logic valve (80), acts upon the back pressure of check valve (C) of the arm spool and presses the check valve.

(2) Main circuit

1) Feed circuit

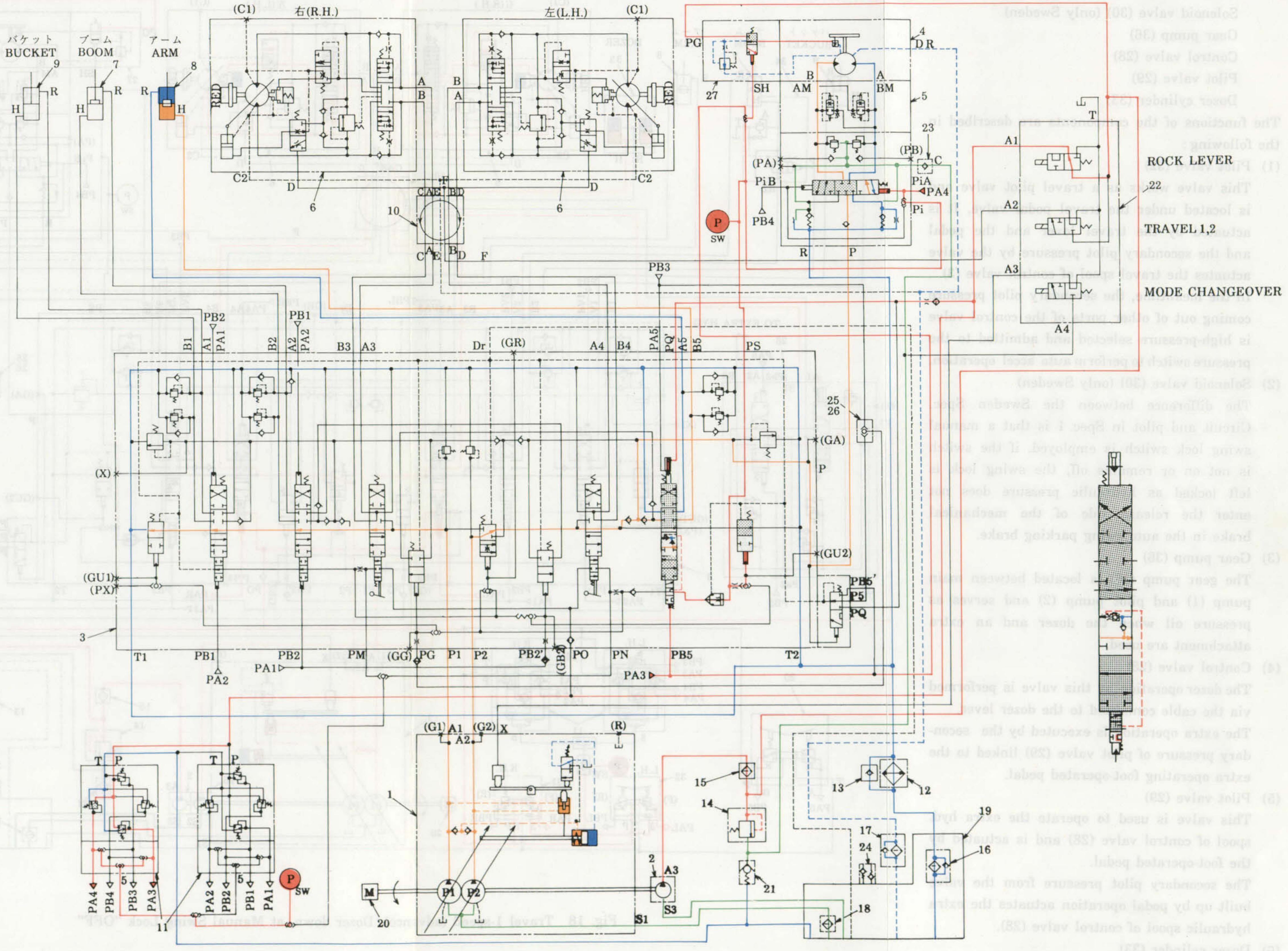
The oil delivered by the No.2 variable displacement pump is supplied to both the arm cylinder and the swing motor by the parallel circuit.

2) Return circuit of arm cylinder

Since the returned oil from the rod (R) of the arm cylinder is shut off by check valve (C) of the arm spool in the control valve, it pushes check valve (B) open and is recycled to the cylinder. As the result the pressure of the head (H) of the cylinder rises.

3) Swing priority circuit

If arm action and swing action are performed at the same time, the arm digging pressure rises as mentioned above and is supplied to the swing motor on a priority basis.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PG
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SH
AM
BM
27
4
5
23
(PA)
PiB
(PB)
PiA
PA4
Pi
PB4
P
SW
10
6
6
C2
C2
D
D
F
PB3
PB2
PB1
B1
A1
PA1
B2
A2
PA2
B3
A3
Dr
(GR)
A4
B4
PA5
PQ
A5
B5
PS
25
26
(GA)
(X)
(GU2)
(GU1)
(PX)
PB5'
P5
PQ
3
T1
PB1
PB2
PM
(GG)
PG
P1
P2
PB2'
(GB)
PO
PN
PB5
T2
PA1
PA2
PA3
(G1)
A1
A2
(G2)
X
(R)
1
15
14
13
12
19
17
24
16
21
18
2
A3
S3
S1
M
P1
P2
20
PA4
PB4
PB3
PA3
PA2
PB2
PB1
PA1
11
P
SW
ROCK LEVER
A1
22
A2
TRAVEL 1,2
A3
MODE CHANGEOVER
A4
T
H
R
9
7
8

Fig. 17 Arm digging/ swing left (swing priority) operation circuit

4.7 DOZER & EXTRA SPEC. CIRCUIT

This circuit consists of the following components added to Spec. 1:

Pilot valve (32)
Solenoid valve (30) (only Sweden)
Gear pump (36)
Control valve (28)
Pilot valve (29)
Dozer cylinder (33)

The functions of the components are described in the following:

(1) Pilot valve (32)

This valve works as a travel pilot valve and is located under the travel pedal valve. It is actuated by the travel lever and the pedal and the secondary pilot pressure by the valve actuates the travel spool of control valve (3).

In the meantime, the secondary pilot pressure coming out of other ports of the control valve is high-pressure selected and admitted to the pressure switch to perform auto accel operation.

(2) Solenoid valve (30) (only Sweden)

The difference between the Sweden Spec. Circuit and pilot in Spec. 1 is that a manual swing lock switch is employed. if the switch is not on or remains off, the swing lock is left locked as hydraulic pressure does not enter the release side of the mechanical brake in the auto swing parking brake.

(3) Gear pump (36)

The gear pump (36) is located between main pump (1) and pilot pump (2) and serves as pressure oil when the dozer and an extra attachment are used.

(4) Control valve (28)

The dozer operation by this valve is performed via the cable connected to the dozer lever.

The extra operation is executed by the secondary pressure of pilot valve (29) linked to the extra operating foot-operated pedal.

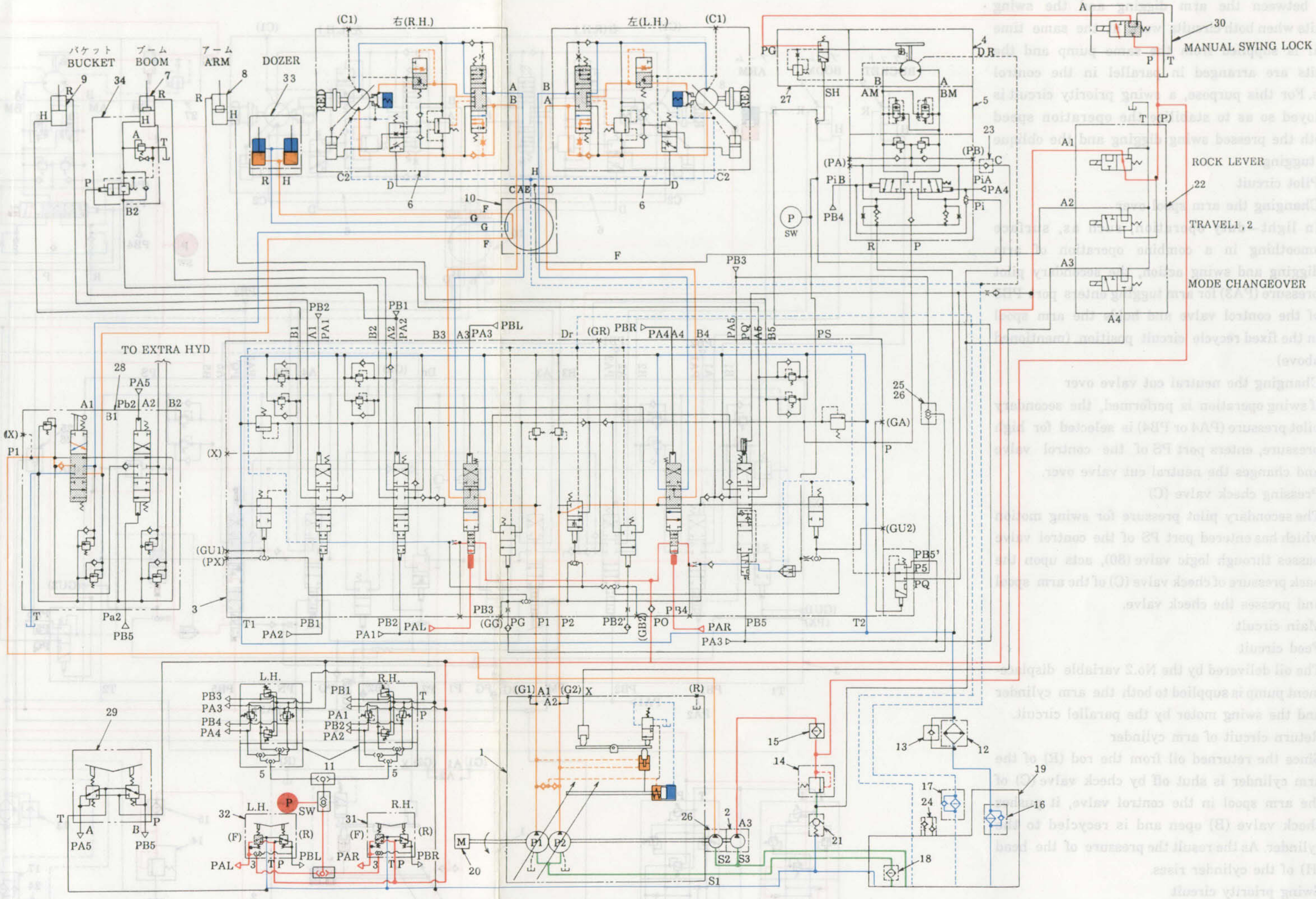
(5) Pilot valve (29)

This valve is used to operate the extra hyd. spool of control valve (28) and is actuated by the foot-operated pedal.

The secondary pilot pressure from the valve built up by pedal operation actuates the extra hydraulic spool of control valve (28).

(6) Dozer cylinder (33)

The dozer cylinder moves the dozer plate on the front of the chassis up and down.


バケット
BUCKET
ブーム
BOOM
アーム
ARM
DOZER
右(R.H.)
左(L.H.)
(C1)
C2
CAE
TO EXTRA HYD
30
MANUAL SWING LOCK
ROCK LEVER
TRAVEL1, 2
MODE CHANGEOVER
A1
A2
A3
A4
PG
SH
AM
BM
D.R.
L.H.
R.H.
SW
M
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S1
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S3
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Fig. 18 Travel 1-speed (advance)/Dozer down, at Manual Swing Lock "OFF"

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KOBELCO

SHOP MANUAL SK60

SWING SYSTEM

LE15

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Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE1506E K

1. OPERATION OF SWING SYSTEM

1.1 SPECIAL FEATURES OF THE SWING SYSTEM

1) Pilot pressure control
Swing operation is controlled by pilot pressure, and swing movement is according to the stroke of the control lever.

2) Automatic swing brake
A mechanical brake is applied automatically except during simultaneous swing and arm retraction.

3) Delayed braking by pressure reducing valve
To prevent the swing brake from being applied during swing due to inertia, brake application is delaved.

4) Swing priority circuit
When arm operation and swing operation are carried out simultaneously, oil is supplied to the swing motor on a priority basis.

5) Shockless valve
This valve absorbs the shock when swinging is stopped.

6) Swing alarm lamp
When the swing/rear working light switch is turned on, a swing alarm lamp lights up when swing is initiated.

1.2 MAIN PIPING CONNECTION

Table 1 (Connecting port signs)

	Hydraulic Oil Tank	Pump ①	Control Valve③	Control Valve④
Supply	Tank ➤	S1 – A2	– P2 – P –	➤ P
Return	Tank ◀	Oil Cooler	T	◀ R

1.3 SWING OPERATION

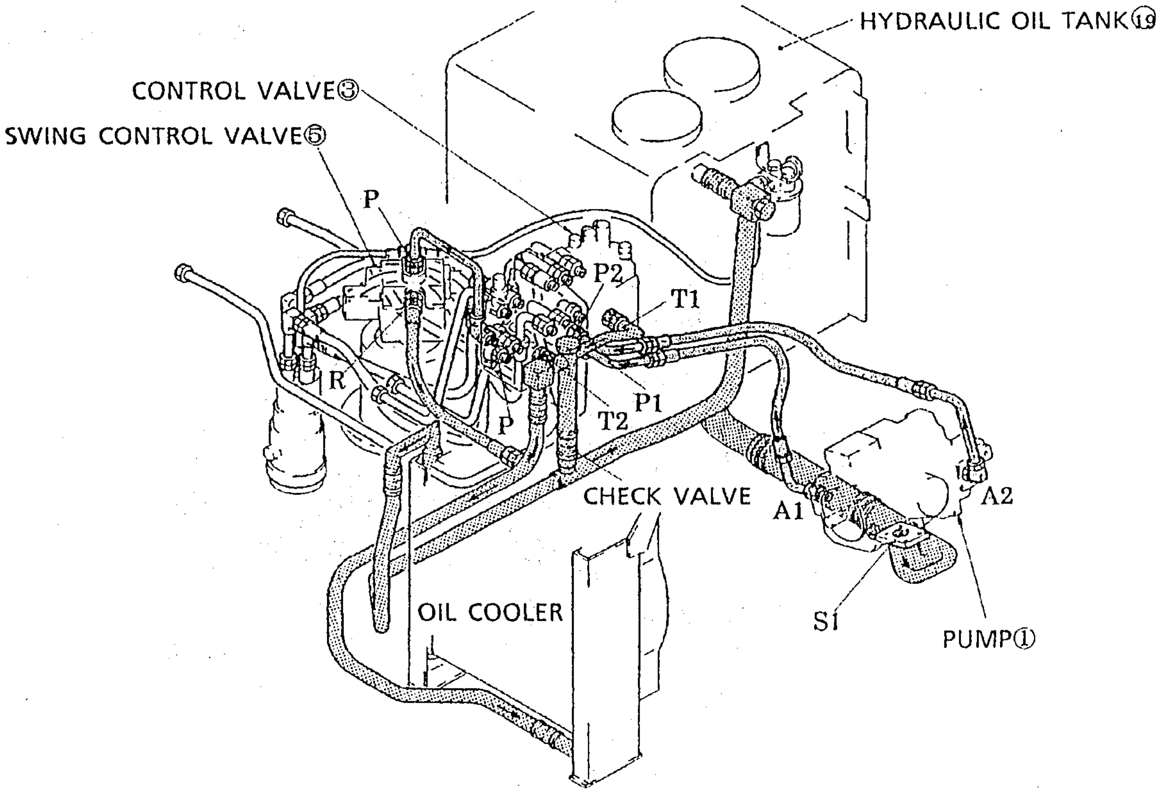

Fig. Drive oil flow at swing motion

1. OPERATION OF SWING SYSTEM

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   This valve absorbs the shock when swinging is stopped.
6) Swing alarm lamp
   When the swing / rear working light switch is turned on, a swing alarm lamp lights up when swing is initiated.
7) Manual swing lock
   If the manual swing lock switch is turned off, the swing parking is left operating. Unless the manual swing lock switch is not turned on, swing does not work even if swing operating is performed.

1.2 MAIN PIPING CONNECTION

Table 1 (Connecting port signs)

	Hydraulic Oil Tank	Pump ①	Control Valve③	Control Valve④
Supply	Tank ▷	S1 − A2	− P2 − P	▷ P
Return	Tank ◁	Oil Cooler	T	◁ R

1.3 SWING OPERATION

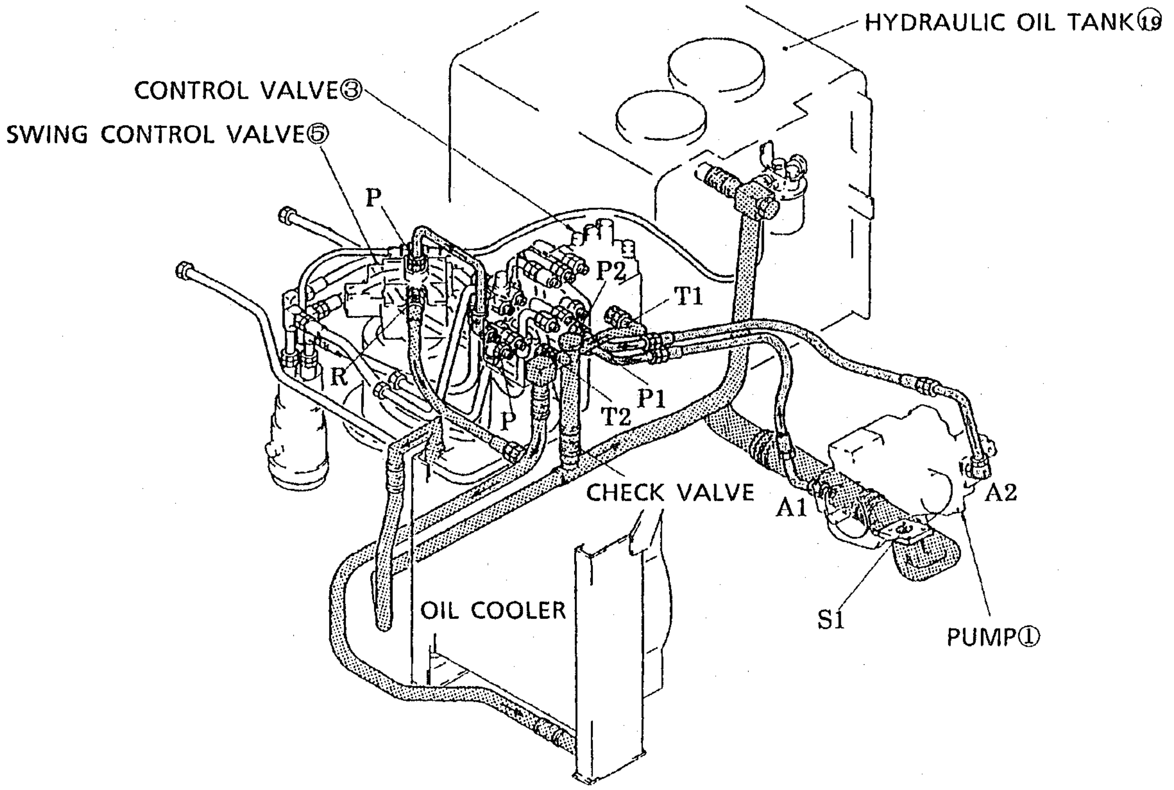

Fig. Drive oil flow at swing motion

1) If the engine is driven, the oil discharged from the No.2 pump is supplied to port P of separately mounted swing control valve (5) via port P2 and port P of control valve (3).
2) If the swing lever is operated, the spool of swing control valve (5) is changed over to send in pressurized oil into the swing motor and to turn the motor.
3) A reduction unit is connected to the swing motor with splines. The reduction gear rotates the swing pinion by converting the motors high-speed rotation to low-speed, high-torque rotaion.
4) The swing pinion engages with the swing bearing internal gear. Since the swing bearing internal gear is bolt-fitted to the lower frame, the pinion rotates around the bearing.
5) The rotating pinion is integrated in the swing reduc-tion unit shaft. This reduction unit is bolt-fitted to the upper frame, so the outer race rotates.
6) Oil returns from the swing motor to the hydraulic oil tank through R port of the control valve and oil cooler. If the resistance in the return pipe increases enough, the oil returns to the hydraulic oil tank through the check valve.

1.4 PILOT PRESSURE HYDRAULIC FLOW FOR THE SWING SYSTEM

(1) Pilot pressure ports
The pilot pressure ports of each component are shown in table 2 and figure 2.
(2) Chenging the pilot pressure circuits
Operating type can be changed by piping.
(3) Grouping of swing system pilot pipings by services
1) Primary pilot pressure (delivery) circuit
2) Control (secondary pilot pressure) circuit
3) Brake release command pressure circuit
4) Swing priority signal circuit
5) Swing flasher signal circuit
6) Boost pressure (assist) circuit
7) Drain circuit

Table 2 (Connecting port signs)

		Tank	Gear pump	Pilot filter	Relief valve	Solenoid valve	Block	Pilot valve	Swing control valve (5)	Motor (4)	Reducing valve (27)	Control valve	Pump
Componet No.		19	2	15	14	22	34	11	5			3	1
Primary pilot pressure circuit			S3 A3 →	IN OUT →	P → P →	P ← A1 A2 A3 A4 →	P·P →	P			PG	→ PO	
Operating circuit	Swing RH							PB4 →	PiA				
	Swing LH							PA4 →	PiB				
Brake release command	Arm pull							PA3 →				→ PB5	
	Swing								Pi →		SH ←		
Swing priority signal circuit												→ PS	
Swing alarm lamp control circuit											ⓅSW		
Boost circuit					T →				→ C				
Drain circuit		←				T	T	T				T	

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7) Manual swing lock circuit
8) Drain circuit

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Componet No.		19	2	15	14	22	34	11	4			3	1	23
Primary pilot pressure circuit			S3 A3 →	IN OUT →	P P	P ← A1 A2 A3 A4 →	P·P →	P			(PG)	→ PO		
Manual swing lock circuit											PG ←			→ P A
Operating circuit	Swing RH							PA4 →	PiA					
	Swing LH							PA4 →	PiB					
Brake release command	Arm pull							PA3 →				→ PB5		
	Swing								Pi →		→ SH ←			
Swing priority signal circuit												→ PS		
Swing alarm lamp control circuit											ⓅSW			
Boost circuit					T →				→ C					
Drain circuit		←				T	T	T				T		

1.5 OPERATION OF SWING PILOT PRESSURE CIRCUITS

1) Primary pilot pressure (delivery) circuit
In the pilot pressure circuit up to port P of the pilot valve (11), oil is directed from port A3 of the gear pump attached to the main pump, through the solenoid valve (22) , and to port P of the pilot valve.
Oil entering port P of the solenoid valve (22) changes direction according to the position of the lever lock switch installed on the control stand. When the control lever on the stand is pushed forward to the work position, oil flows from port A1 of the solenoid valve to port P of the pilot valve (11).

2) Operating (secondary pilot pressure) circuit
The flow of oil in the swing control circuit from the solenoid valve (22) to the swing control valve (5) is as follows. When the swing lever is moved for swing right or swing left, oil is directed from port PA4 or PB4 of the pilot valve to port PiB or PiA of the swing control valve. This pilot pressure shifts the spool in the swing control valve, opening the main circuit from the control valve to the swing motor.

3) Brake release command pressure circuit
The hydraulic oil in two circuits of the shift signal circuit of the reducing valve enters port SH, opening the swing brake release circuit.
One is the circuit coming out of port Pi of swing control valve (5) (the high-pressure selected pilot pressure which enters ports PiA and PiB of the swing control valve), another being the circuit with the arm digging operating pressure by way of port PB5 of control valve (3).

4) Swing priority signal circuit
The swing priority circuit is from port Pi of the swing control valve to port PS of the control valve (3). When the arm is being retracted while swinging, oil at port PS of the control valve acts to throttle the return oil from the arm cylinder, supplying oil to the swing motor on a priority basis.

5) Swing alarm lamp
When swing operation is performed, the secondary pilot pressure acts on the pressure switch. This turns on the switch electrically and lights the swing flasher lamp.

6) Boost pressure (assist) circuit
Back pressure of 7kgf/cm^2 (100psi) is constantly acting between port T of relief valve (14) and port C of the swing control valve, and when the inner pressure of the swing motor falls below that level, pressure is replenished from port C to prevent cavitation of the swing motor.

7) Drain circuit.
The drain from components returns to the tank from port T.

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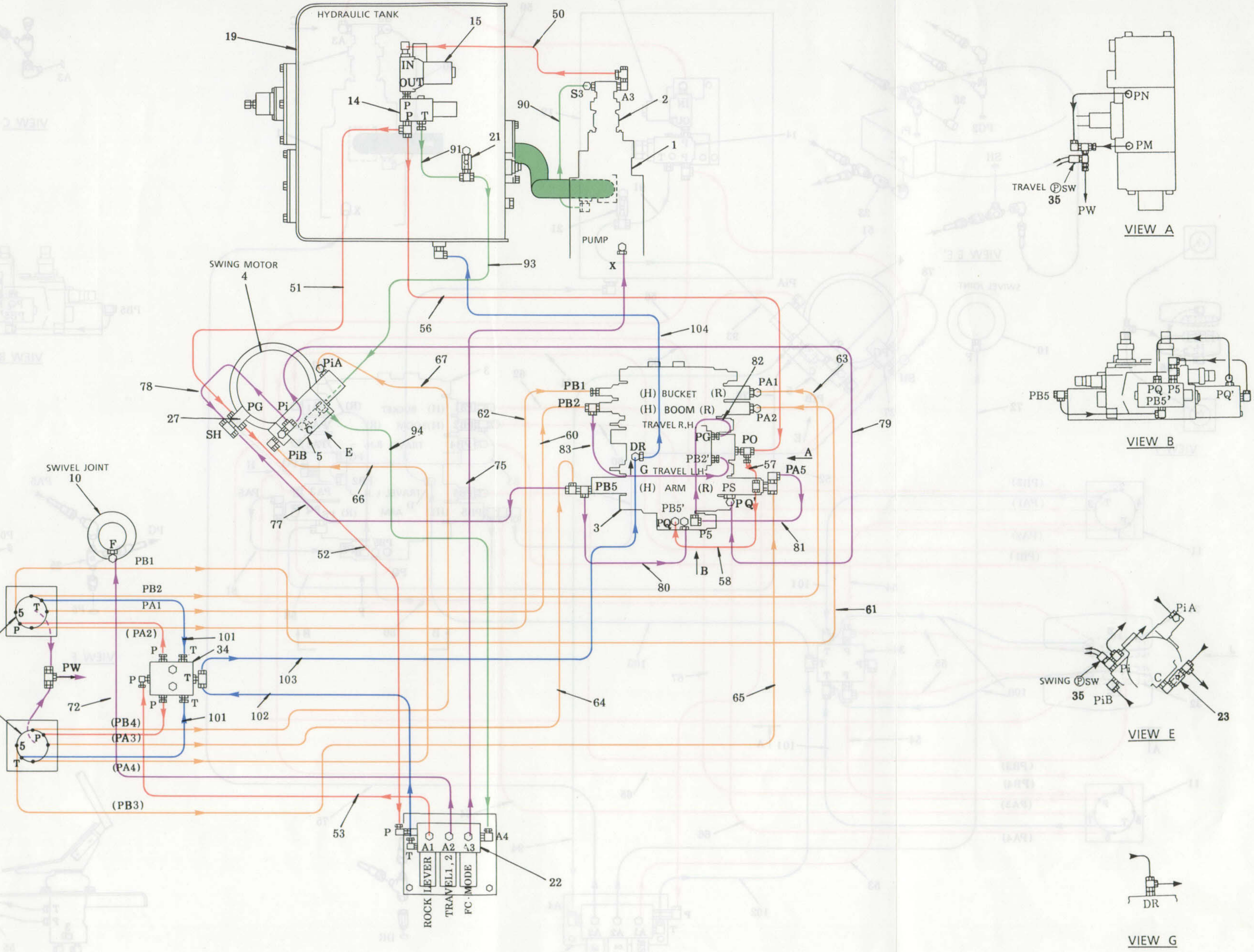
7) Manual swing lock circuit
The manual swing lock circuit is so designed that it does not work by careless swing operation. The manual swing lock circuit is operated by providing a solenoid valve halfway on the parking brake release line in which the primary pilot pressure is present and switching over the solenoid valve by means of a switch on the control board.
OFF : Manual swing lock
ON : Swing operation enabled
When the switch is off, the pressurized oil from port PG of the reducing valve (27) ceases to reach and makes the swing parking impossible to be released. This increases the parking brake above a swing torque and disables swing action.

8) Drain circuit.
The drain from components returns to the tank from port T.

No.	Component Name	No.	Component Name	No.	Component Name
1	Main pump	14	Pilot relief valve	27	Reducing valve
2	Gear pump	15	Line filter	31	Travelling pilot valve R.H
3	Main control valve	19	Hydraulic tank	32	Travelling pilot valve L.H
4	Swing motor ass'y	21	Check valve	34	Block
5	Swing control valve	22	Solenoid valve	35	Pressure switch
10	Swivel joint	23	Check valve		
11	Operating pilot valve	25	Tee & Ball		

Piping			Component No. & Conecting port		Remarks
No.	Classification		From	To	
50	Pink color	Primary pilot pressure circuit	2-OUT	15-IN	Primary pilot pressure delivery
51			14-P	27-PG	For Automatic swing parking release
52			27-PG	22-P	For Solenoid valve (22)
53			22-A1	34-P	For Block (34)
54			34-P	11-P	For Operating pilot valve (11)
55			34-P	31,32-P	For Travelling pilot valve (31, 32)
56			14-P	3-P0	Servo pressure for control valve side by-pass
57			3-P0	3-PQ'	Arm confluence valve changeover for Arm spool
58			3-PQ'	3-PQ	Arm confluence valve changeover for Sequence
60	Orange color	Operating circuit (Secondary pilot pressure circuit)	11-3	3-PB2	Boom raise (PA1)
61			11-4	3-PA2	Boom lower (PB1)
62			11-1	3-PB1	Bucket digging (PA2)
63			11-2	3-PA1	Bucket discharge (PB2)
64			11-7	3-PB5	Arm digging (PA3)
65			11-8	3-PA5	Arm extending (PB3)
66			11-5	5-PiB	Swing L. H. (PA4)
67			11-6	5-PiA	Swing R. H. (PB4)
72	Violet color	Command or Signal circuit	22-A2	10-F	Travelling motor 2-speed changeover
75			22-A3	1-X	FC mode changeover
77			3-PB5	27-SH	Reducing valve changeover in Arm digging
78			5-Pi	27-SH	Reducing valve changeover in Swing
79			5-Pi	3-PS	Swing priority in Swing and Arm digging
80			3-PB5	3-PB5'	Arm confluent in Arm heavy digging
81			3-PA5	3-P5	Arm confluent in Arm extending
82			3-P5	3-PG	Arm confluent in Arm heavy digging or Arm extending
83			3-PB2	3-PB2'	Boom raise conflux
84			3-PA2	34-P	Holding valve, boom lower command circuit
86	Orange color	Steering circuit	32-1	3-PA3	Travel steering circuit L.H. advance
87			32-2	3-PB3	Travel steering circuit L.H. retreat
88			31-2	3-PA4	Travel steering circuit R.H. advance
89			31-1	3-PB4	Travel steering circuit L.H. retreat
90	Grean color	Servo circuit	19	2-S3	Gear pump
91			14-T	21	Relief valve for Tank circuit
93			21	5-C	Swing boost pressure
94			5-C	22-A4	Boost pressure in FC mode
100	Blue color	Drain circuit	31,32-T	34-T	From Travelling valve (31, 32)
101			11-T	34-T	From Operating valve (11)
102			22-T	34-T	From Solenoid valve (22)
103			34-T	3-DR	From Block
104			3-Dr	19	From Main control valve (3)


HYDRAULIC TANK
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PUMP
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SWING MOTOR
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ROCK LEVER
TRAVEL1, 2
FC-MODE
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PM
TRAVEL Ⓟ SW
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PW
VIEW A
PB5
PQ P5
PB5'
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VIEW B
PiA
Pi
C
SWING Ⓟ SW
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PiB
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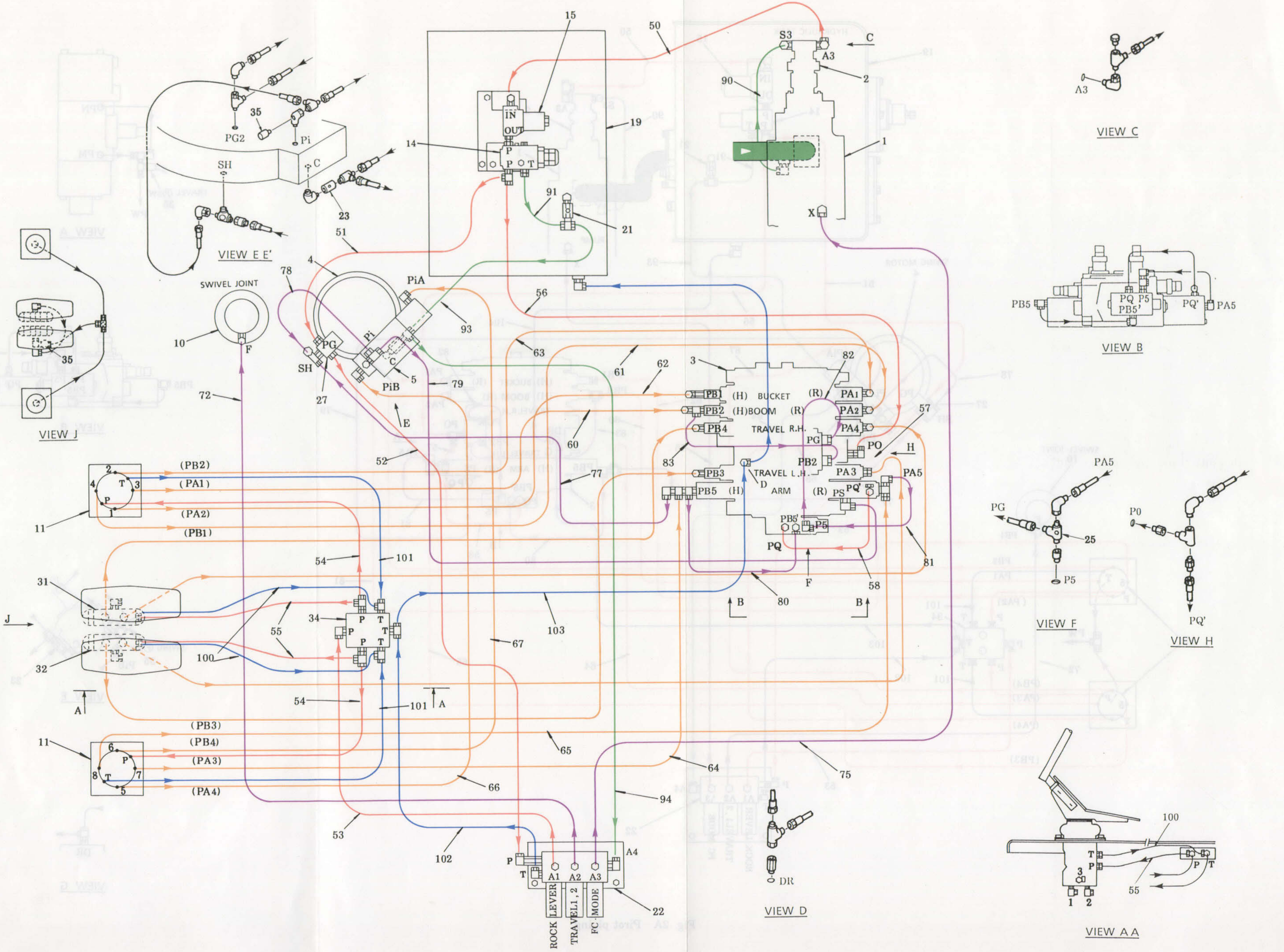
VIEW E
DR
VIEW G

Fig. 2A Pirot piping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TRAVEL R.H.
PA4
PG
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PB2
PA3
PA5
PB3
TRAVEL L.H.
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ARM
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101
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(PB4)
(PA3)
(PA4)
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102
P
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A1
A2
A3
A4
22
ROCK LEVER
TRAVEL1, 2
FC·MODE
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VIEW D
A3
VIEW C
PB5
PQ
P5
PB5'
PQ'
PA5
VIEW B
PA5
PG
25
P5
VIEW F
P0
PQ'
VIEW H
100
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P
3
1
2
P
T
55
VIEW A A

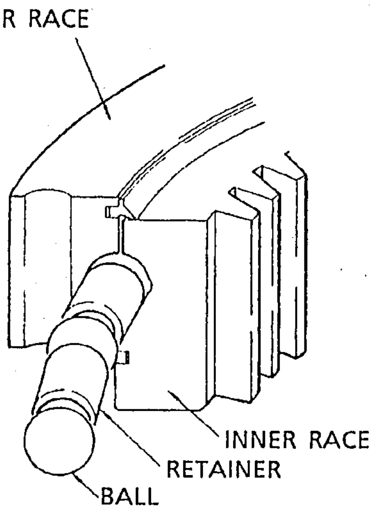
Fig. 2B Pirot piping

2. SWING RING

The construction of the swing system is shown in figure 3.

2.1 SLEWING RING (SEE FIGURE 4)

The slewing ring is a ball bearing structure. Between the inner race (2) and the outer race (1) there are balls (3) and retainers (4) installed alternately. The outer race (1) is fixed to the upper frame and the inner race (2) is fixed to the lower frame, both with cap screws.
The swing motor pinion rotates in mesh with the gear installed on the inner race (2), rotating the upper frame.


OUTER RACE
INNER RACE
RETAINER
BALL

No.	NAME	Q'ty
1	OUTER RACE	1
2	INNER RACE	1
3	BALL	84
4	RETAINER	84
5	SEAL	1
6	SEAL	1
7	GREASE FITTING	2
8	TAPER PIN	1
9	PLUG	1

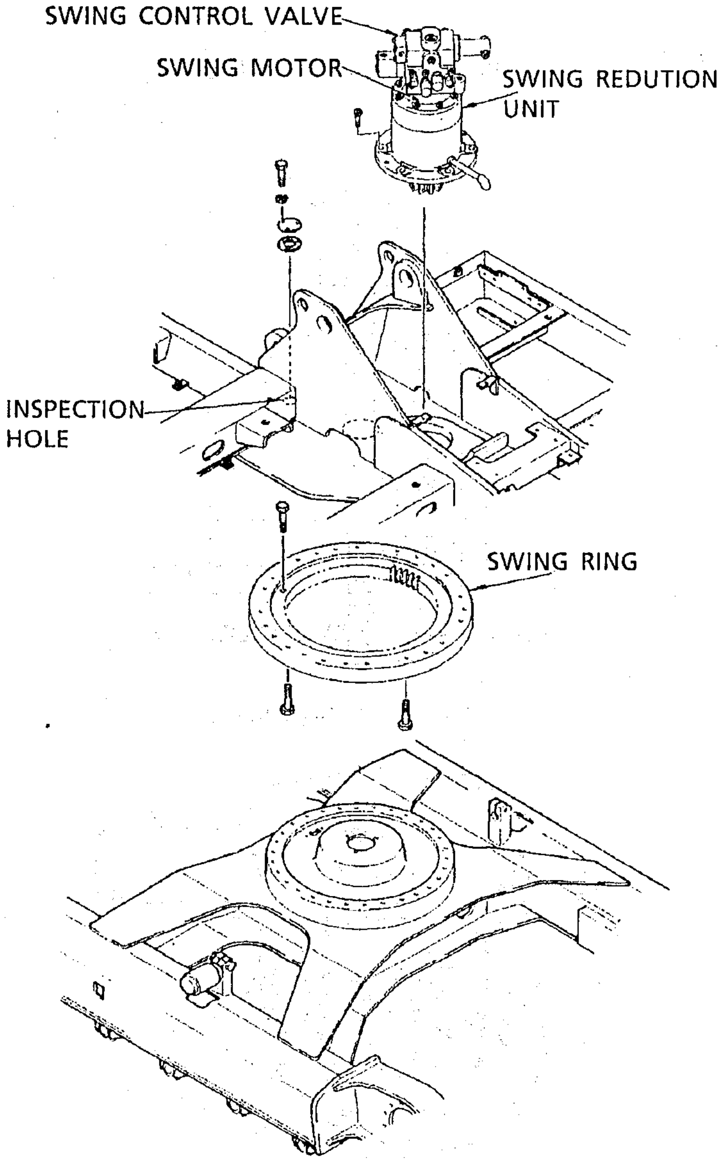

SWING CONTROL VALVE
SWING MOTOR
SWING REDUTION UNIT
INSPECTION HOLE
SWING RING

Fig. 3

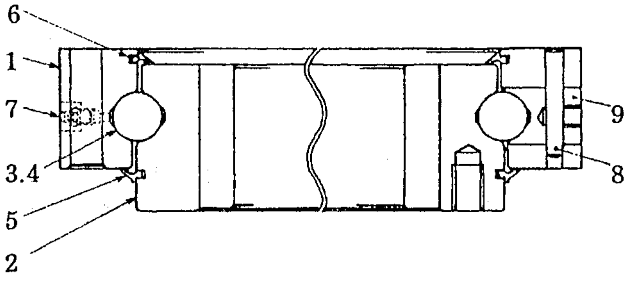


Fig. 4 Swing ring

Table 3

Item	Specification
Module	8
Pressure angle	20°
Number of teeth	75
Ball size	15/16″
Weight	110kg (243 lbs)

2.2 SWING GREASE BATH (SEE FIG. 3 FIG. 5)

A grease bath method is employed for the swing gear. The method extends greasing intervals greatly and insures positive lubrication as the swing pinion moves in the grease. Furthermore, the swivel boot that provides a hermetically sealed-off construction prevents entry of sludge, sand, soil and other foreign matter from outside, thereby maintaining the quality of grease for an extended period of time. The swing gear and pinion may by inspected through inspection holes.

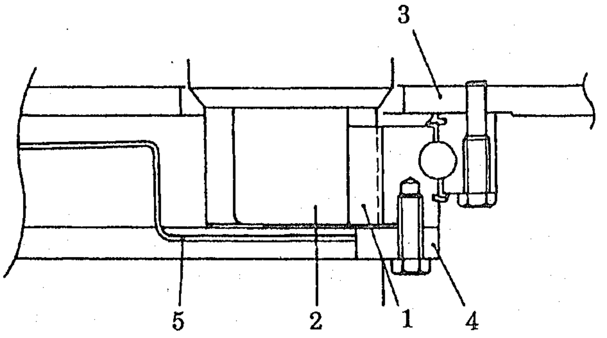


Fig. 5

NO.	NAME	Q'ty	NO.	NAME	Q'ty
1	SWING GEAR	1	4	UNDER FRAME	1
2	SWING PINION	1	5	SWIVEL BOOT	1
3	SWING FRAME	1			

3. REMOVING AND INSTALLING OF SWING CONTROL VALVE

3.1 REMOVING THE SWING CONTROL VALVE

1) After lowering the working attachment to the ground, stop the engine, unscrew nut A on the air breather on the hydraulic oil tank, and press the valve at the center of the breather to purge the air from the tank.

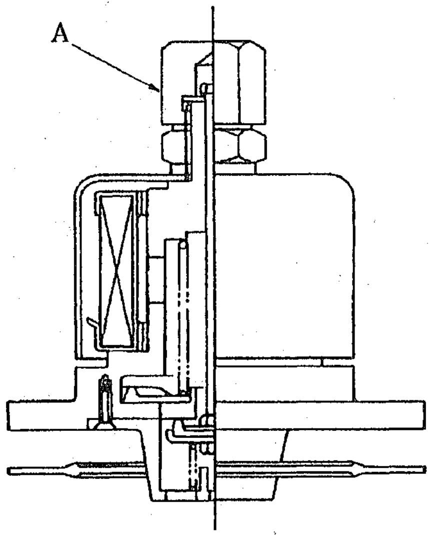


Fig. 6 Air breather

2) Remove the hydraulic oil piping leading to the swing control valve, and plug each port.

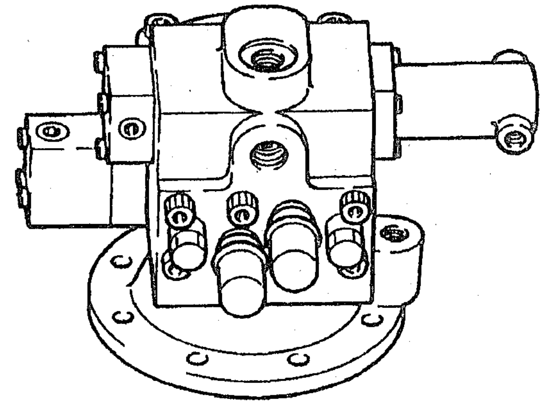


Fig. 7 Remove the piping

3) Attach a wire rope to the swing control valve in a figure-8 pattern, and suspend the valve, leaving a little slack in the rope.

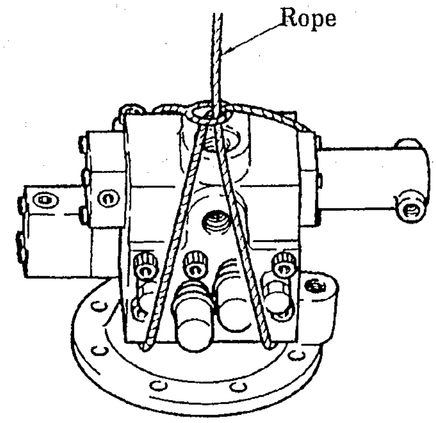


Fig. 8 Attach the rope in a fiqure-8 pattern

4) Romove the hex socket head bolts (A) holding the swing control valve.

☞ The swing control valve weighs about 21 kg. (46 lbs)

5) Do not forget to plug the swing motor mounting ports to shut off dust, dirt and other foreign matter.

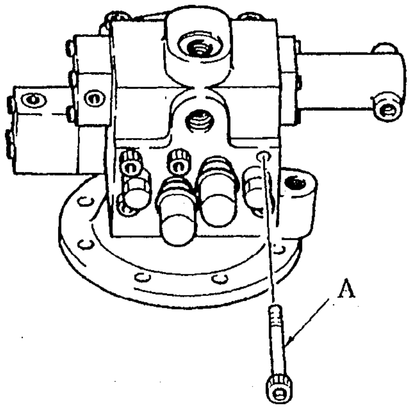


Fig. 9 Remove the mounting bolts A

3.2 INSTALLING THE SWING CONTROL VALVE

1) Installation is the reverse order of removal.
2) Inspect the flange surface of the motor and both flange faces at the side of the valve to which the swing control valve and remove burr and stain, if any, from the surfaces.

3) Make sure that O rings are fitted on the swing control valve side and temporarily install the control valve to the swing motor by means of six socket bolts (A).

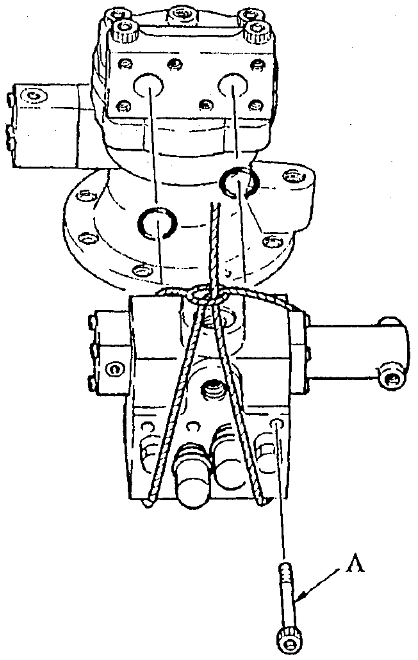


Fig. 10 Temporarily tighten mounting bolts A

4) Tighten the hex socket head bolts (A) to the specified torque of 7±0.7kgf-m. (51±5.1ft-lbs)

5) Reconnect to the swing control valve all the hydraulic piping disconnected for removal.

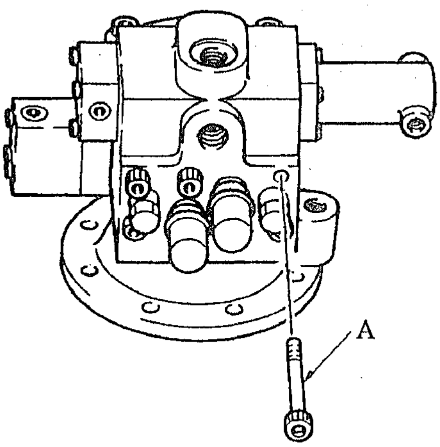


Fig. 11 Tighten to specified torque

4. REMOVING AND INSTALLING OF SWING MOTOR ASSEMBLY

4.1 REMOVING THE SWING MOTOR

☞
- Here is given a method of removing the swing motor and the swing control valve together. (in an assembled condition).
- The weight of the swing motor and the swing control valve combined is about 45kg. (99 lbs)

1) Disconnect the hydraulic oil piping leading to the swing control valve and swing motor, and plug each port.

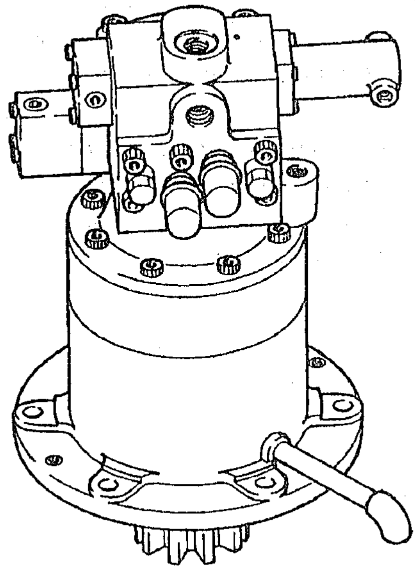


Fig. 12 Remove the piping

2) Remove the swing motor mounting hex socket head bolts (B) (M10) to remove the swing motor from the swing reduction gear unit.

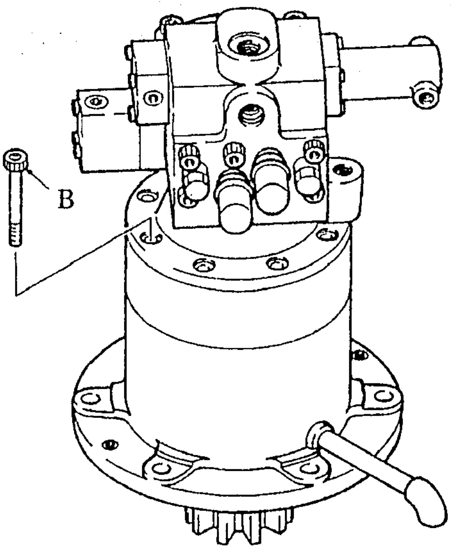


Fig. 13 Remove motor mounting bolts

3) Screw 2 eye-bolts into the lifting bolt holes (M10) on top of the swing motor as shown in the drawing, and suspend the motor with a wire rope.
If the swing motor does not come off the reduction gear unit easily, insert a screwdriver into the removal groove at the flange (see Fig. 14) to pry it off.

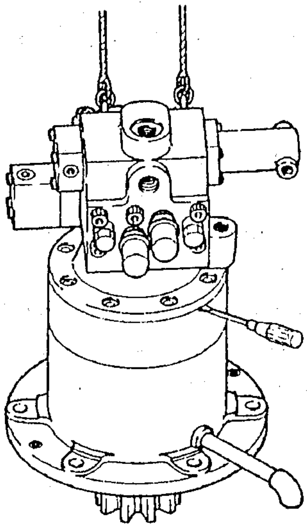


Fig. 14 Remobe motor from reduction gear unit

4.2 INSTALLING THE SWING MOTOR

Install the swing motor by reversing the order of the steps for removal, paying attention to the following.

☞
- Apply three bond 1215 to the mating faces of the swing motor and the reduction gear unit.
- Apply three bond 1360k to the threads of the hex socket head bolts (B) for mounting the swing motor.

1) Screw 2eye-bolts into the lifting bolt holes (M10) on top of the swing motor near the nameplate, lift the motor with a wire rope, lower it onto the mounting face of the reduction gear unit, and tighten the hex socket head bolts (B) to the specified torque of 6.7±0.7 kgf-m. (48±5ft-lbs)

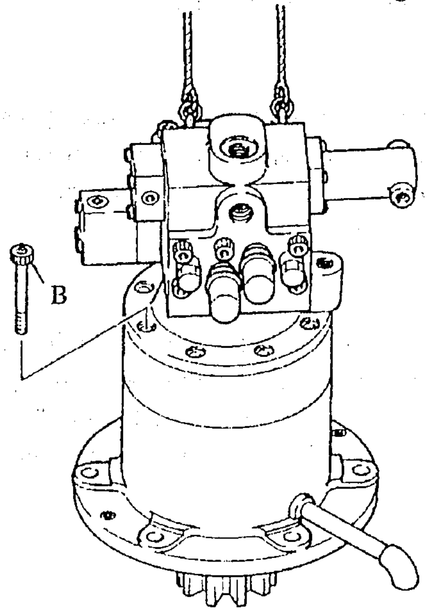


Fig. 15 Tighten motor mounting bolts

2) Reconnect to the swing motor and the swing control valve all the hydraulic piping disconnected for removal.

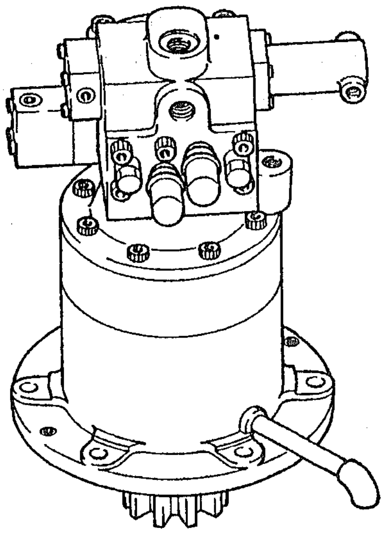


Fig. 16 Reconnect the hydraulic piping

5. REMOVING AND INSTALLING OF SWING REDUCTION UNIT

5.1 REMOVING THE SWING REDUCTION GEAR UNIT

1) Disconnect the hydraulic oil piping leading to the swing control valve and the swing motor, and plug each port.
2) Remove the hex socket head bolts (C) (M16) fixing the swing reduction gear unit. Extension lever : about 600 mm (23.62 in) long

☞ ● Putting match-marks on the reduction gear unit and the upper frame will facilitate installation.

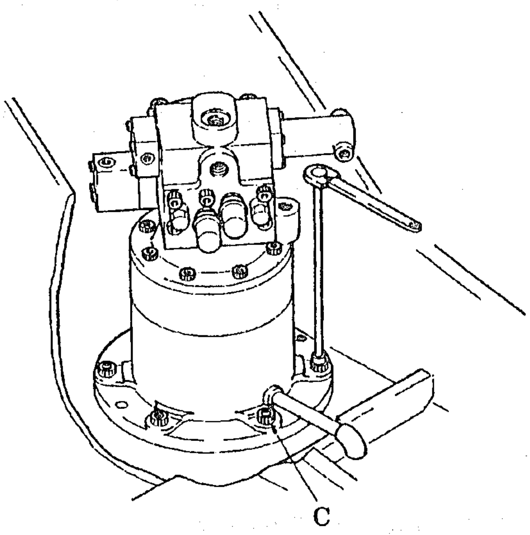


Fig. 17 Remove mounting bolts (M16)

3) Screw 2 eye-bolts into the lifting bolt holes (M10) on the top of the swing motor near the nameplate, and suspend the motor with a wire rope.

4) Remove the swing motor mounting bolts (B) joining the motor to the reduction gear unit, and lift the motor off. (Refer to "5.1 removal and installation of swing motor assembly")

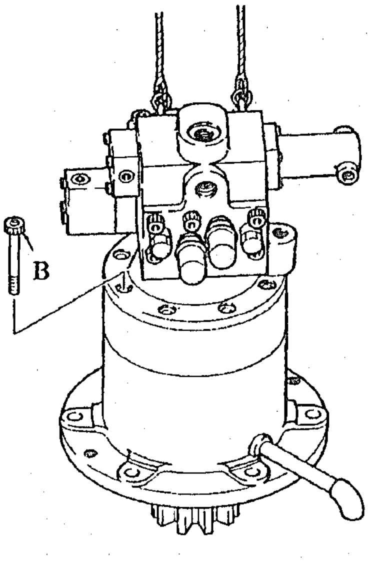


Fig. 18 Remove the motor assembly

5.2 INSTALLING THE SWING REDUCTION GEAR UNIT

1) Remove completely any burrs or contaminants on the mating faces of the upper frame and the swing reduction gear unit.

2) Mount the swing motor assembly on top of the swing reduction gear unit. (Refer to "5.2 installing the swing motor")
3) Screw 2 eye-bolts into the lifting bolt holes (M10) on top of the swing motor near the nameplate, and lift the motor with a wire rope.

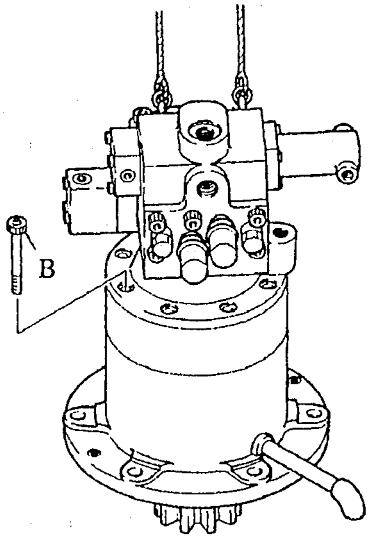


Fig. 19 Install the motor assembly

☞ Apply three bond 1215 to the mating faces before installing the reduction gear unit.

4) Tighten the hex socket head bolts (C) (M16) fixing the swing reduction gear unit to the specified torque of 25±2.5kgf·m. (181±18 ft-lbs)

☞ Apply three bond 1360k to the hex socket head bolts (C) for mounting the reduction gear unit.

5) Reconnect to the swing control valve and the swing motor all the hydraulic piping disconnected for removal.

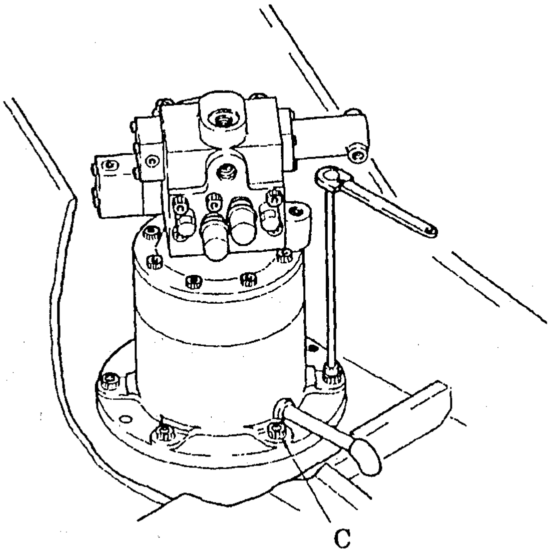


Fig. 20 Tighten mounting bolts (M16)

6. REMOVING AND INSTALLING OF SWING RING

6.1 REMOVING THE SWING RING

1) Remove the upper frame off the machine proper. (Refer to the separate manual "Upper Frame")
2) Remove the capscrews (E) that fix the inner race to the swing bearing.

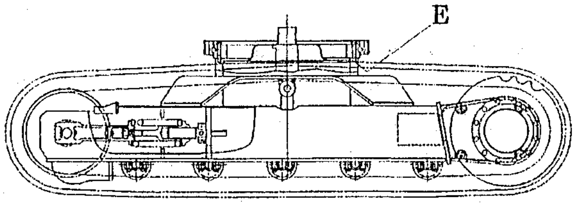


Fig. 21

3) Install two lifting rings to the swing bearing and lift it with a crane till it comes off.
Weight of swing bearing: approx. 110kg (243 lbs).

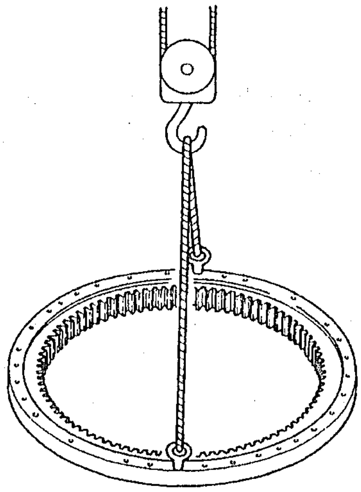


Fig. 22 How to lift the slewing ring

6.2 INSTALLING THE SWING RING

1) Before installing the swing bearing, remove dust and oil that may stay on the matching surface of the swing ring and the installing surface of the lower frame.

2) Set the swing ring on the lower frame in such a way that the "S" mark on the inner race is located on the left-hand side of the machine.

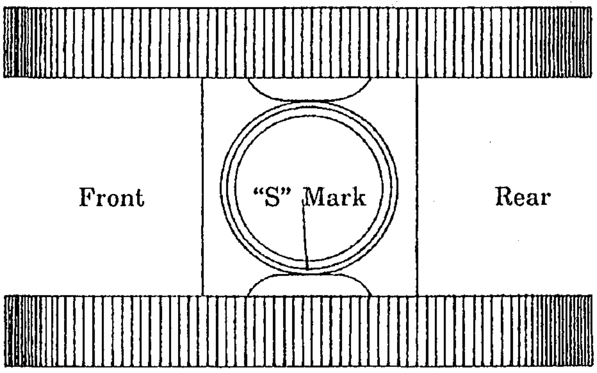


Fig. 23 Position of the S mark on the slewing ring

3) Apply three bond 1360k to the threads of the cap screws, and install them in sequence.

4) Tighten a pair of capscrews located 180 degrees apart, to 15kg·m (108ft-Ibs) torgue.
5) Next, tighten all the cap screws to the specified torque of 28.5±2.5 kgf-m. (206±18ft-Ibs)
6) After installing the slewing ring on the lower frame, install the upper frame on the slewing ring. (Refer to the separate manual "Upper Frame")

☞ Apply three bond 1215 all around the inside of the cap screw holes in the mounting faces of the upper frame and the slewing ring.

7. MAINTENANCE STANDARDS

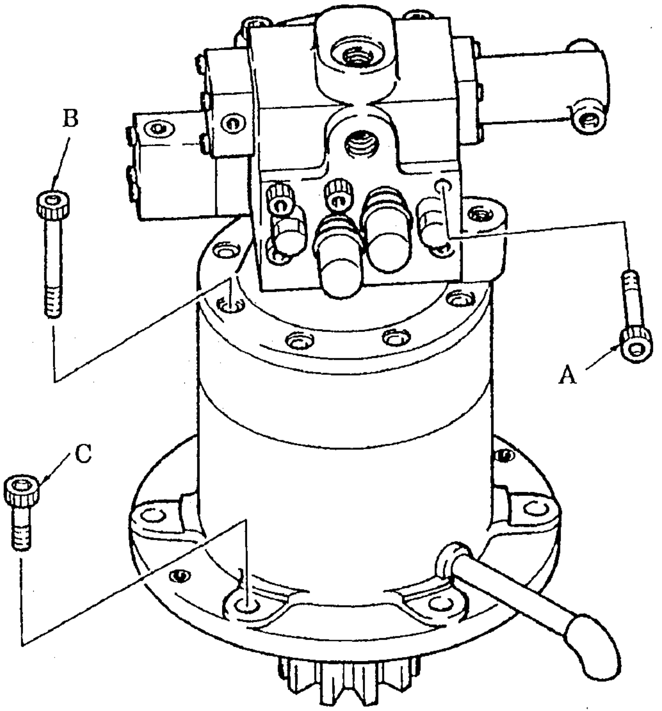


Fig. 24

Table 4

Unit: kgf·m (ft-Ibs)

Symbol	Item	Standard value	Remedy
A	Hex socket head bolts fastening swing control valve	7±0.7 (51±5)	Retighten
B	Hex sockets head bolts fastening swing motor and swing reduction unit	6.7±0.7 (48±5)	Hex socket head bolt
C	Hex sockets head bolts fastening swing reduction unit and upper frame	25±2.5 (181±18)	Apply three bond 1360 k (Locktite #242) Apply three bond 1215 (Locktite#515) to the mating faces of the swing motor and the reduction gear unit. Retighten.

☞ • For the tightening torques of the swing ring and others, refer to a separate manual "Upper Frame"

Book code No. S5LE1806E

KOBELCO

SHOP MANUAL SK60

TRAVEL SYSTEM

LE18

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Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE1806E K

1. CONSTRUCTION OF LOWER MACHINERY

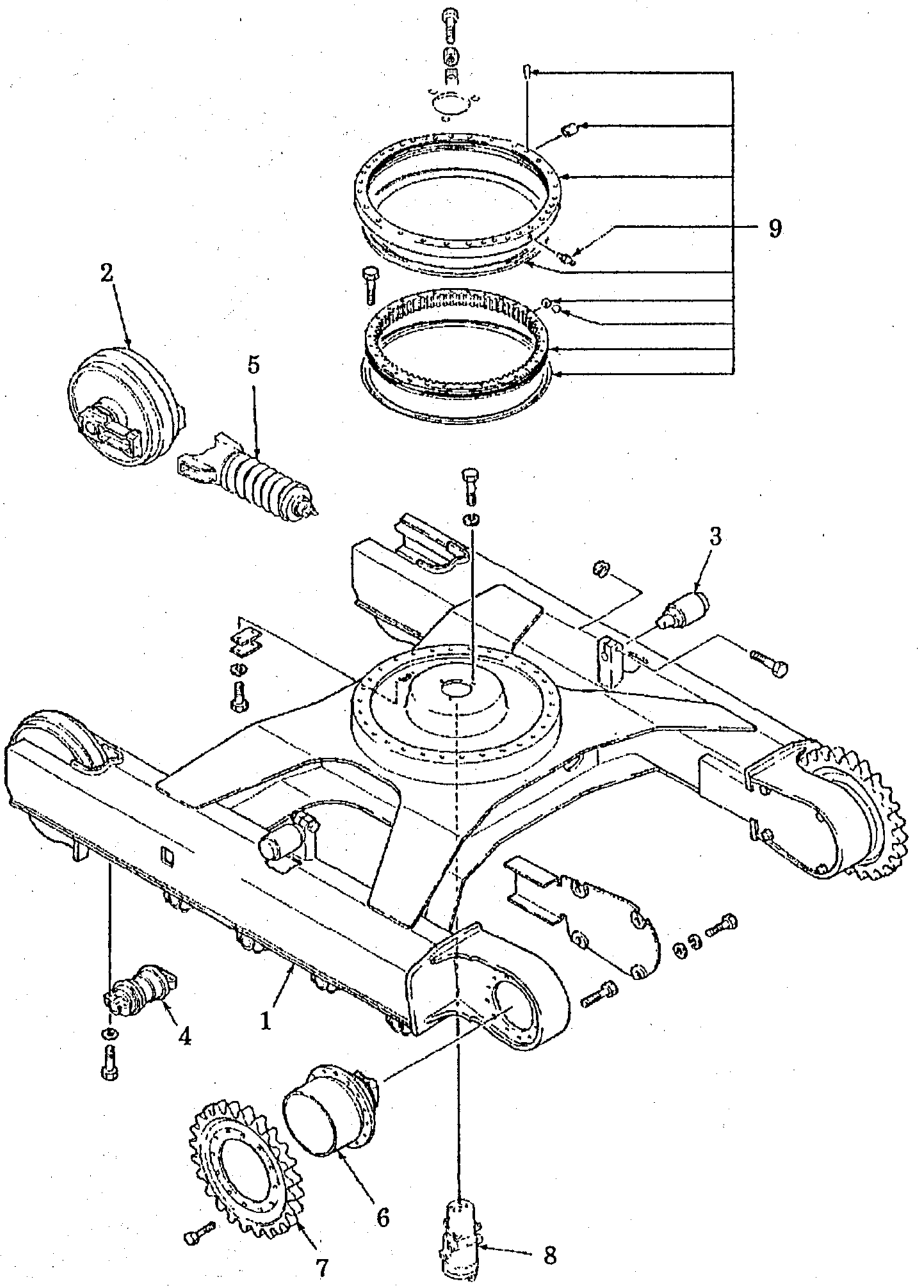


Fig. 1

No.	NAME	Q' ty		No.	NAME	Q' ty	
		Standard	Rubber			Standard	Rubber
1	LOWER FRAME	1	←	7	SPROCKET Z=21	2	←
2	IDLER ASSEMBLY	2	←	8	SWIVEL JOINT	1	←
3	UPPER ROLLER ASSEMBLY	1×2	←	9	BEARING (SWING)	1	←
4	LOWER ROLLER ASSEMBLY	5×2	←	10	TRACK LINK	38×2	–
5	TRACK SPRING ASSEMBLY	2	←	11	CRAWLER SHOE (RUBBER)	–	1×2
6	MOTOR (TRAVEL)	2	←				

2. OPERATION

2.1 SPECIAL FEATURES OF THE TRAVEL SYSTEM

The travel system of this machine has the following special features.

1) Cable-operated spool
   The control valve spool is operated via a cable linked to the travel control lever.
2) Two travel speeds
   A travel 2-speed switch is used to select Low or High speed.
3) Straight travel
   A travel priority circuit is incorporated to provide straight travel during simultaneous travel and operation of a working attachment.
4) Travel highest pressure
   Travel highest pressure is furnished so that the highest pressure is provided for travel to the destination.

2.2 HYDRAULIC FLOW

(1) Piping between the hydraulic oil tank and the control valve (see Table 2 and Figure 2)

Table 2 (Connecting port signs)

Component / Circuit	Oil Function Tank ⑲	Pump ①	Control valve ③
Feed	Tank ▷—	S1 — A1 → S1 — A2 →	▷ P1 ▷ P2
Return	Tank ◁—	Oil cooler	—◁ T

(2) Piping between the control valve and the brake valve (see Table 2 and Figure 2)

Table 3 (Connecting port signs)

Action		Valve: Control valve ③	Swivel joint ⑩		Brake valve ⑥	
			Upper	Lower	LH	RH
RH Advance	Feed	B3	C	C		B
	Return	A3	A	A		A
LH Advance	Feed	B4	D	D	A	
	Return	A4	B	B	B	
RH Retreat	Feed	A3	A	A	–	A
	Return	B3	C	C	–	B
LH Retreat	Feed	A4	B	B	B	
	Return	B4	D	D	A	

(3) Relation between pump and travel motor drive

Table 4

	Pump ①	Control Valve ③	Travel motor ⑥
Travel independent Travel	A1 A2	P1 P2	RH (Advance · Retreat) LH (Advance · Retreat)
Travel/ATT Travel straight	A2	P1	RH (Advance · Retreat) LH (Advance · Retreat)

(4) Drain circuit

Table 5

Travel motor ⑥	Swivel joint ⑩	Swing motor ④	Drain filter ⑰	Tank ⑲
Dr ▷—	E – E	Dr	IN · OUT —	▷

2. OPERATION

2.1 SPECIAL FEATURES OF THE TRAVEL SYSTEM

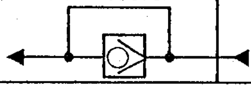
The travel system of this machine has the following special features.

1) Pilot operation method
   The secondary pilot pressure of the pilot valve linked to the travel operation lever actuates the control valve spool.
2) Two travel speeds
   A travel 2-speed switch is used to select Low or High speed.
3) Straight travel
   A travel priority circuit is incorporated to provide straight travel during simultaneous travel and operation of a working attachment.
4) Travel highest pressure
   Travel highest pressure is furnished so that the highest pressure is provided for travel to the destination.

2.2 HYDRAULIC FLOW

(1) Piping between the hydraulic oil tank and the control valve (see Table 2 and Figure 2)

Table 2 (Connecting port signs)

Component / Circuit	Oil Function Tank ⑲	Pump ①	Control valve ③
Feed	Tank ▶—S1	—┬ A_1 ——▶ └ A_2 ——▶	P_1 P_2
Return	Tank ◀—— Oil cooler 	——◀	T

(2) Piping between the control valve and the brake valve (see Table 2 and Figure 2)

Table 3 (Connecting port signs)

Action		Control valve ③	Swivel joint ⑩ Upper	Swivel joint ⑩ Lower	Brake valve ⑥ LH	Brake valve ⑥ RH
RH Advance	Feed	B3	C	C		B
	Return	A3	A	A		A
LH Advance	Feed	B4	D	D	A	
	Return	A4	B	B	B	
RH Retreat	Feed	A3	A	A	–	A
	Return	B3	C	C	–	B
LH Retreat	Feed	A4	B	B	B	
	Return	B4	D	D	A	

(3) Relation between pump and travel motor drive

Table 4

	Pump ①	Control Valve ③	Travel motor ⑥
Travel independent Travel	A_1 A_2	P_1 P_2	RH (Advance · Retreat) LH (Advance · Retreat)
Travel/ATT Travel straight	A_2	P_1	RH (Advance · Retreat) LH (Advance · Retreat)

(4) Drain circuit

Table 5

Travel motor ⑥	Swivel joint ⑩	Swing motor ④	Drain filter ⑰	Tank ⑲
Dr ▶—	E – E	Dr	IN · OUT ——	——▶

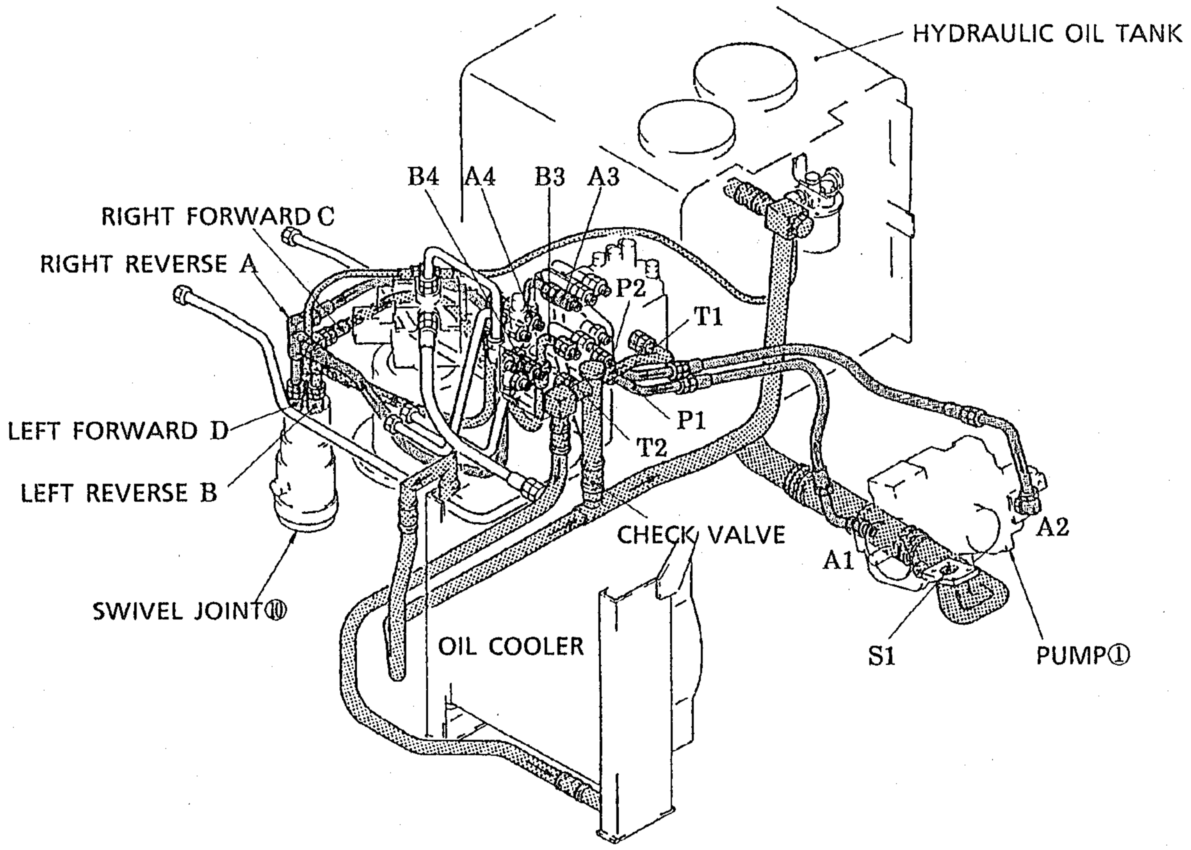
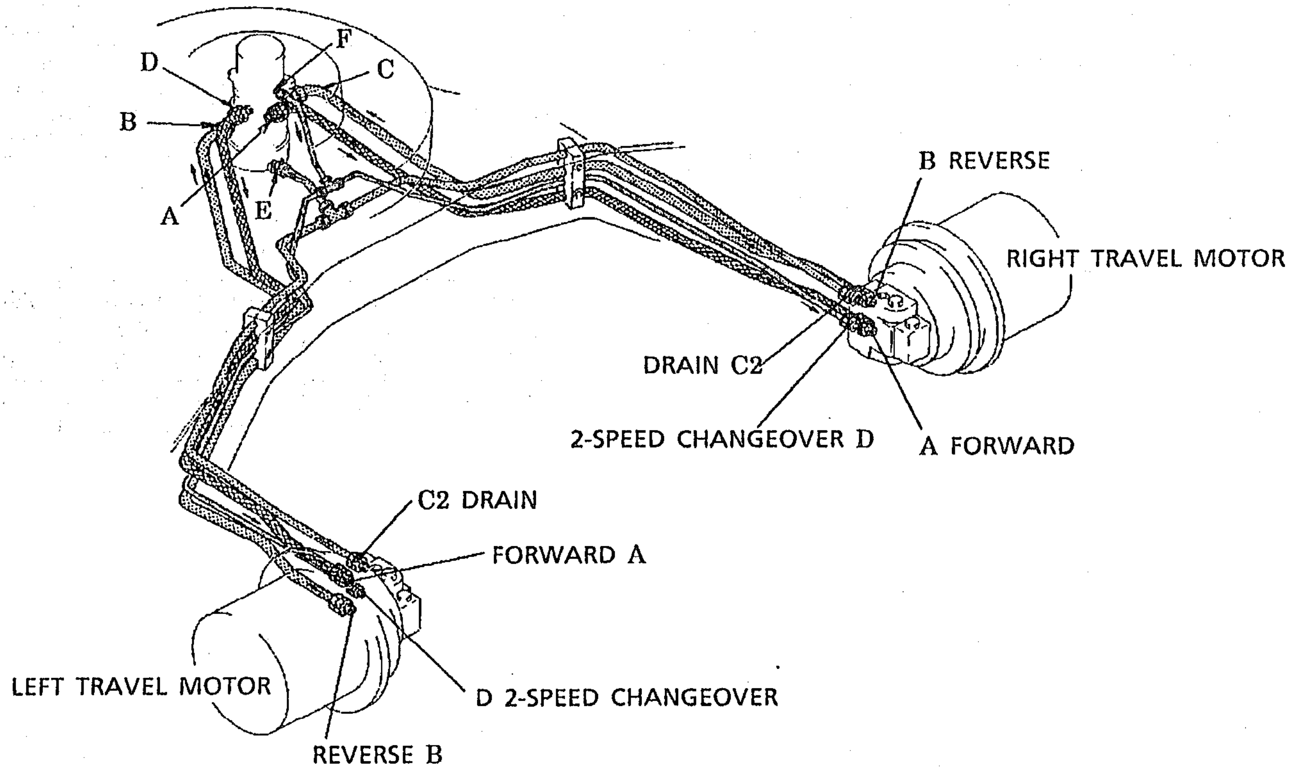

HYDRAULIC OIL TANK
B4
A4
B3
A3
RIGHT FORWARD C
RIGHT REVERSE A
P2
T1
P1
T2
LEFT FORWARD D
LEFT REVERSE B
CHECK VALVE
A2
A1
SWIVEL JOINT⑩
OIL COOLER
S1
PUMP①

Fig. 2 Piping between pump and swivel joint

☞ The arrows show flow direction when the machine is traveling forward


D
F
C
B
A
E
B REVERSE
RIGHT TRAVEL MOTOR
DRAIN C2
2-SPEED CHANGEOVER D
A FORWARD
C2 DRAIN
FORWARD A
LEFT TRAVEL MOTOR
D 2-SPEED CHANGEOVER
REVERSE B

☞ The arrows show flow direction when the machine is traveling forward。

fig. 3 Hydraulic piping on lower frame

2.3 PILOT HYDRAULIC FLOW

Pilot hydraulic flow is made up of:

1) Primary pilot pressure circuit
2) 2-speed travel changeover circuit
3) Auto accel signal circuit
4) Drain circuit

Table 6

	Tank	Gear pump	Pilot filter	Pilot relief	Solenoid valve Rock lever	 Travel 1, 2	 Mode changeover		Swing motor	Control valve	Pressure SW	Center joint	Travel motor
Component No.	19	2	17	14	22				4	3		10	6
Primary pilot pressure circuit	→	S3 A3 →	IN OUT →	P P →	P A1	A2	A3	A4	→ PG	→ P0 PM PN			
2-speed travel changeover circuit						A2 →						→ F · F	→ D → D
Auto accel signal circuit										→	SW		
Drain circuit	←				T					Dr			

2.4 OPERATION OF PILOT HYDRAULIC FLOW

1) Primary pilot pressure circuit

   Oil from the gear pump (2) flows into the ports of the components as shown in Table 6. The flow paths shown apply when the lever lock is in the unlock position.

2) Two-speed travel speed selection

   When the "Tortoise & Hare " mark on the knob on the travel right lever is pressed, the solenoid valve (22) is shifted, and oil is directed form port A2 to port D of the travel variable displacement motor, switching the travel speed from 1st to 2nd, or vice versa.

3) Auto accel signal circuit

   The primary pilot pressure enters port P0 of the control valve (called servo circuit) and connects with the side bypass circuit of the travel spool.

   When the travel spool is in neutral, the pressurized oil flow downstream is out off by the travel spool in the uppermost stream.

   When the travel spool is shifted, the path downstream is opened.

   Then the pressurized oil from port PM and PN of the control valve enters the pressure switch to turn on and serves as an electric switch for the selection of the auto accel.

4) Changing over of the travel priority (travel straight) valve

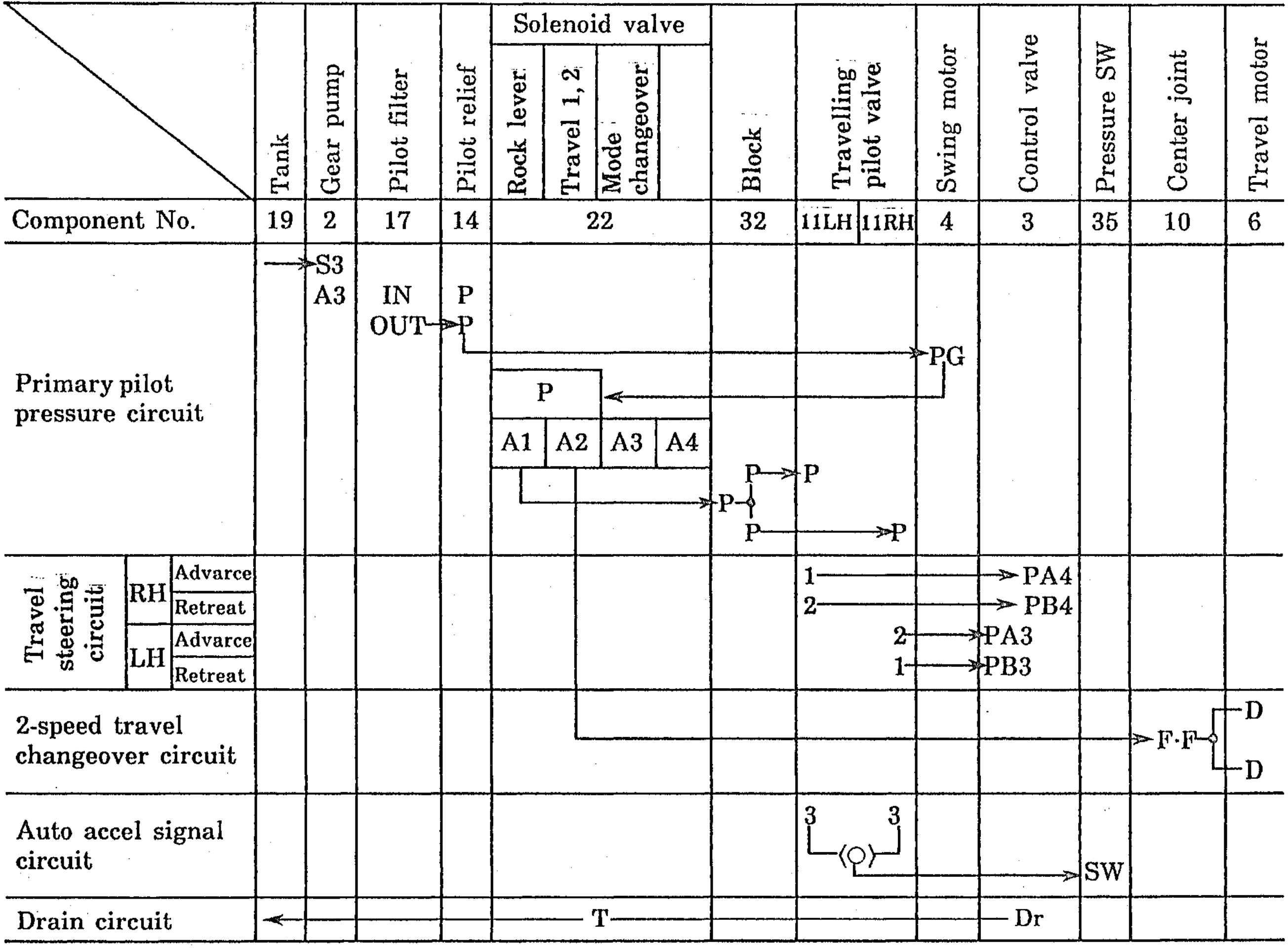
   The pressurized oil of the servo which enters port P0 of the control valve, as explained in the above Auto Accel Signal Circuit, changes over the travel straight valve in the composite operation of travel and attachment.

2.3 PILOT HYDRAULIC FLOW

Pilot hydraulic flow is made up of:

1) Primary pilot pressure circuit
2) Travel steering circuit
3) 2-speed travel changeover circuit
4) Auto accel signal circuit
5) Drain circuit

Table 6


Solenoid valve
Tank
Gear pump
Pilot filter
Pilot relief
Rock lever
Travel 1, 2
Mode changeover
Block
Travelling pilot valve
Swing motor
Control valve
Pressure SW
Center joint
Travel motor
Component No.
19
2
17
14
22
32
11LH
11RH
4
3
35
10
6
Primary pilot pressure circuit
S3
A3
IN
OUT
P
P
PG
P
A1
A2
A3
A4
P
P
P
P
P
Travel steering circuit
RH
Advarce
Retreat
LH
Advarce
Retreat
1
2
2
1
PA4
PB4
PA3
PB3
2-speed travel changeover circuit
F·F
D
D
Auto accel signal circuit
3
3
SW
Drain circuit
T
Dr

2.4 OPERATION OF PILOT HYDRAULIC FLOW

1) Primary pilot pressure circuit

   Oil from the gear pump (2) flows into the ports of the components as shown in Table 6. The flow paths shown apply when the lever lock is in the unlock position.

2) Travel steering circuit

   If travel operation is performed, the primary pilot pressure that is in the travel pilot valve (11) goes out of port 1 or 2 of the valve (now called secondary pilot pressure) and actuates the travel spool of the control valve (3).

3) Two-speed travel speed selection

   When the "Tortoise & Hare " mark on the knob on the travel right lever is pressed, the solenoid valve (22) is shifted, and oil is directed form port A2 to port D of the travel variable displacement motor, switching the travel speed from 1st to 2nd, or vice versa.

4) Auto-accel signal circuit

   If sicondary pilot pressure enters the pressure switch, it works as asto−accel.

   If the travel lever or the pedal is actuated, secondary pilot pressure comes out of port 3 of pilot valve (11) linked to it.

No.	Component Name	No.	Component Name	No.	Component Name
1	Main pump	14	Pilot relief valve	27	Reducing valve
2	Gear pump	15	Line filter	31	Travelling pilot valve R.H
3	Main control valve	19	Hydraulic tank	32	Travelling pilot valve L.H
4	Swing motor ass'y	21	Check valve	34	Block
5	Swing control valve	22	Solenoid valve	35	Pressure switch
10	Swivel joint	23	Check valve		
11	Operating pilot valve	25	Tee & Ball		

Piping			Component No. & Conecting port		Remarks
No.	Classification		From	To	
50	Pink color	Primary pilot pressure circuit	2-OUT	15-IN	Primary pilot pressure delivery
51			14-P	27-PG	For Automatic swing parking release
52			27-PG	22-P	For Solenoid valve (22)
53			22-A1	34-P	For Block (34)
54			34-P	11-P	For Operating pilot valve (11)
55			34-P	31,32-P	For Travelling pilot valve (31, 32)
56			14-P	3-P0	Servo pressure for control valve side by-pass
57			3-P0	3-PQ'	Arm confluence valve changeover for Arm spool
58			3-PQ'	3-PQ	Arm confluence valve changeover for Sequence
60	Orange color	Operating circuit (Secondary pilot pressure circuit)	11-3	3-PB2	Boom raise (PA1)
61			11-4	3-PA2	Boom lower (PB1)
62			11-1	3-PB1	Bucket digging (PA2)
63			11-2	3-PA1	Bucket discharge (PB2)
64			11-7	3-PB5	Arm digging (PA3)
65			11-8	3-PA5	Arm extending (PB3)
66			11-5	5-PiB	Swing L. H. (PA4)
67			11-6	5-PiA	Swing R. H. (PB4)
72	Violet color	Command or Signal circuit	22-A2	10-F	Travelling motor 2-speed changeover
75			22-A3	1-X	FC mode changeover
77			3-PB5	27-SH	Reducing valve changeover in Arm digging
78			5-Pi	27-SH	Reducing valve changeover in Swing
79			5-Pi	3-PS	Swing priority in Swing and Arm digging
80			3-PB5	3-PB5'	Arm confluent in Arm heavy digging
81			3-PA5	3-P5	Arm confluent in Arm extending
82			3-P5	3-PG	Arm confluent in Arm heavy digging or Arm extending
83			3-PB2	3-PB2'	Boom raise conflux
84			3-PA2	34-P	Holding valve, boom lower command circuit
86	Orange color	Steering circuit	32-1	3-PA3	Travel steering circuit L.H. advance
87			32-2	3-PB3	Travel steering circuit L.H. retreat
88			31-2	3-PA4	Travel steering circuit R.H. advance
89			31-1	3-PB4	Travel steering circuit L.H. retreat
90	Grean color	Servo circuit	19	2-S3	Gear pump
91			14-T	21	Relief valve for Tank circuit
93			21	5-C	Swing boost pressure
94			5-C	22-A4	Boost pressure in FC mode
100	Blue color	Drain circuit	31,32-T	34-T	From Travelling valve (31, 32)
101			11-T	34-T	From Operating valve (11)
102			22-T	34-T	From Solenoid valve (22)
103			34-T	3-DR	From Block
104			3-Dr	19	From Main control valve (3)

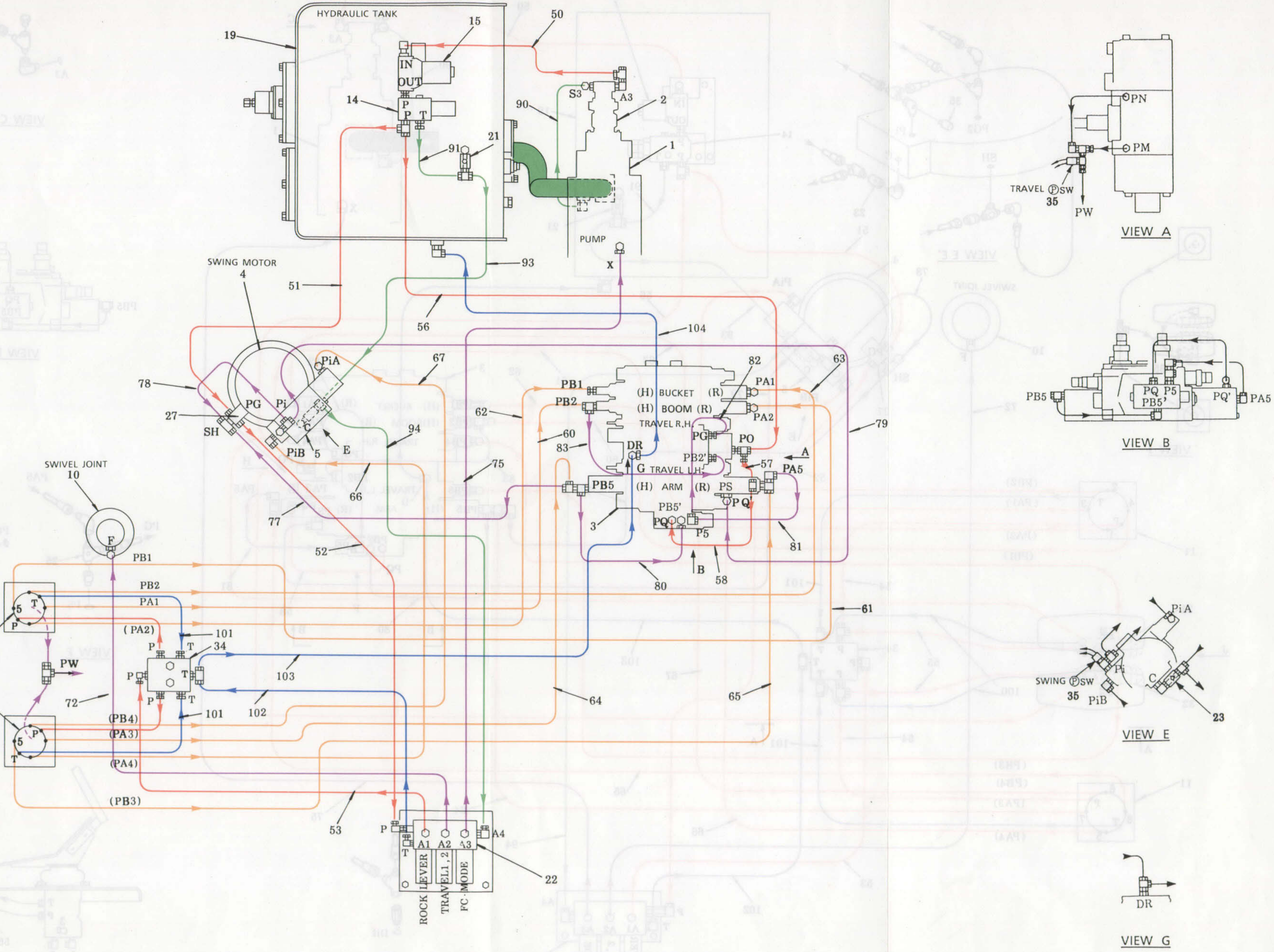

HYDRAULIC TANK
19
15
50
IN
OUT
14
P
T
S3
A3
90
2
1
91
21
PUMP
X
93
51
56
104
SWING MOTOR
4
PiA
67
78
PG
Pi
27
SH
C
E
PiB
5
94
62
PB1
PB2
(H) BUCKET (R)
(H) BOOM (R)
TRAVEL R.H.
82
PA1
63
PA2
79
60
83
DR
PG
PO
A
57
G TRAVEL L.H.
PB2'
PA5
PB5
(H) ARM (R)
PS
PQ
PB5'
PQ
P5
3
77
66
75
81
52
80
58
B
SWIVEL JOINT
10
F
PB1
PB2
PA1
(PA2)
101
34
11
PW
72
103
102
101
(PB4)
(PA3)
(PA4)
(PB3)
64
65
61
53
P
T
A1
A2
A3
A4
22
ROCK LEVER
TRAVEL1, 2
FC-MODE
PN
PM
TRAVEL Ⓟ SW
35
PW
VIEW A
PB5
PQ P5
PB5'
PQ'
PA5
VIEW B
PiA
SWING Ⓟ SW
35
Pi
PiB
C
23
VIEW E
DR
VIEW G

Fig. 4A Pirot piping

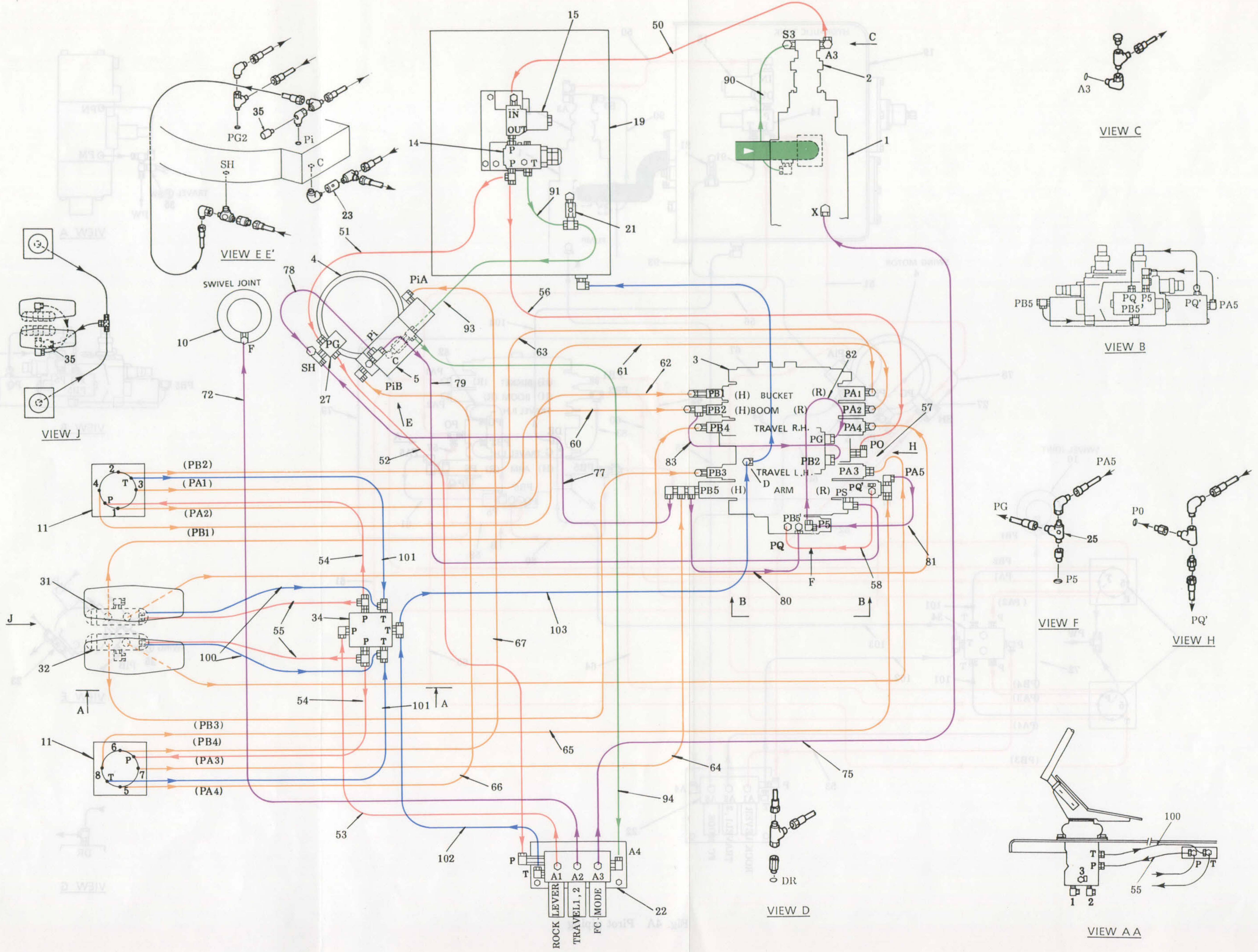

15
50
S3
C
A3
2
90
19
14
IN
OUT
P
T
1
91
21
X
VIEW C
A3
35
PG2
Pi
SH
C
23
VIEW E E'
51
78
4
PiA
93
56
SWIVEL JOINT
10
F
SH
PG
Pi
C
27
PiB
5
79
E
63
61
62
3
82
PB1
(H)
BUCKET
(R)
PA1
PB2
(H)BOOM
PA2
PB4
TRAVEL R.H.
PA4
PG
PO
57
H
PB2
PB3
TRAVEL L.H.
PA3
PA5
D
PB5
ARM
PS
PQ'
PB5'
P5
PQ
83
60
77
52
72
VIEW J
35
11
(PB2)
(PA1)
(PA2)
(PB1)
T
54
101
31
J
34
55
100
32
A
103
67
80
58
81
F
B
VIEW B
PB5
PQ
PB5'
PQ'
PA5
VIEW F
PG
25
P5
PA5
VIEW H
P0
PQ'
(PB3)
(PB4)
(PA3)
(PA4)
6
7
8
5
65
64
75
66
94
53
102
A4
A1
A2
A3
22
ROCK LEVER
TRAVEL1, 2
FC-MODE
VIEW D
DR
VIEW A A
100
55
1
2
3

Fig. 4B Pirot piping

3. TRACK LINK

3.1 REMOVAL AND INSTALLATION PROCEDURES

The numbers in parentheses following each part name in the text correspond to those in Figure 16 and Table 7.

3.1.1 REMOVING THE TRACKS

1) The track link is provided with a pair of master pins (6). Set so the master pin comes in the position of the arrow (front side of idler).

☞ The master pin has a projection at both ends whereby it can be told from other pins.

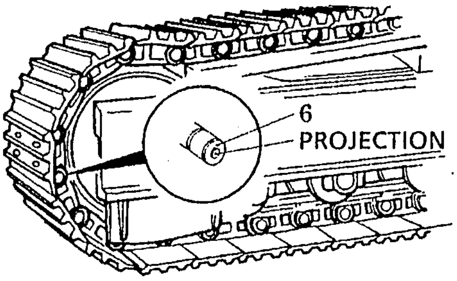


Fig. 5

2) Loosen the track spring adjusting nipple, and bleed grease from the cylinder to loosen shoe tension.

⚠ • Do not loosen the nipple more than one turn.
• If the grease does not come out smoothly, move the machine back and forth.

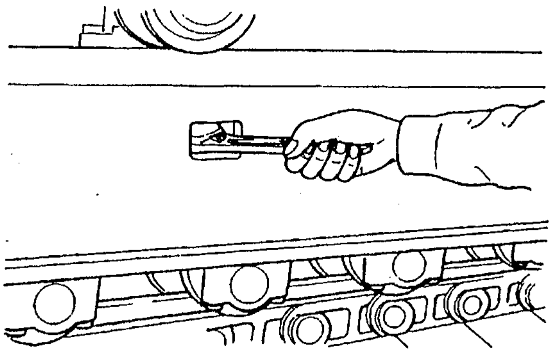


Fig. 6

3) When removing the master pin, do it, using square wooden blocks A and B so large shearing force does not act on the master pin.

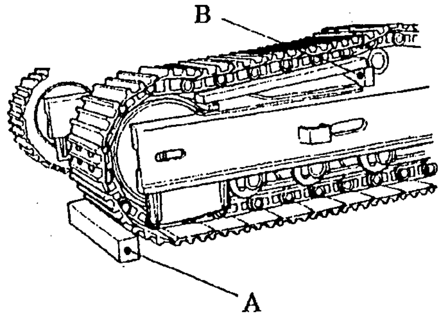


Fig. 7

4) Remover master pin (6) by knocking it via the master pin drawing jig, and then separate collar (7) from the link.

☞ If the master pin is hammered without the shoe plate in place, the track will twist, making it difficult to remove the master pin.

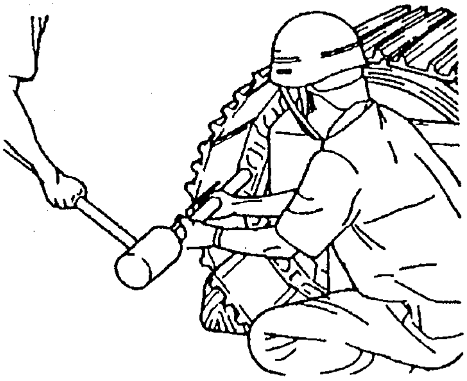


Fig. 8

5) Drive the machine slowly backward and off the track. At this time, drive the machine onto a replacement track or planks.

⚠ Do not get near the sprockets as the track shoe plate may fall on your feet, which is very dangerous.

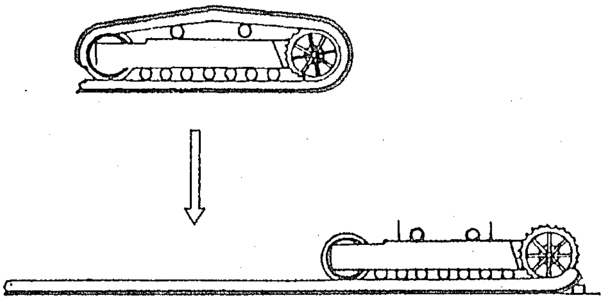


Fig. 9

3.1.2 INSTALLING THE TRACKS

1) While an assistant drives the machine slowly, insert a bar into the master pin bore located at the track end, and help the track engage with the sprocket.

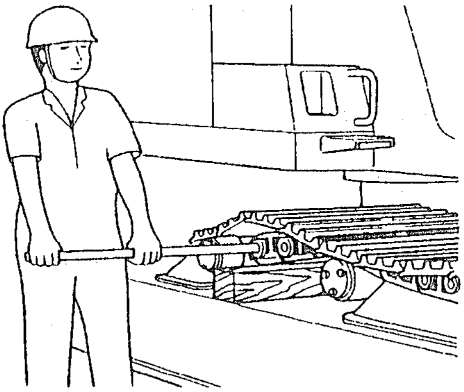


Fig. 10

2) When aligning the master pin bores in the track links, use wooden blocks A and B to join the track ends.

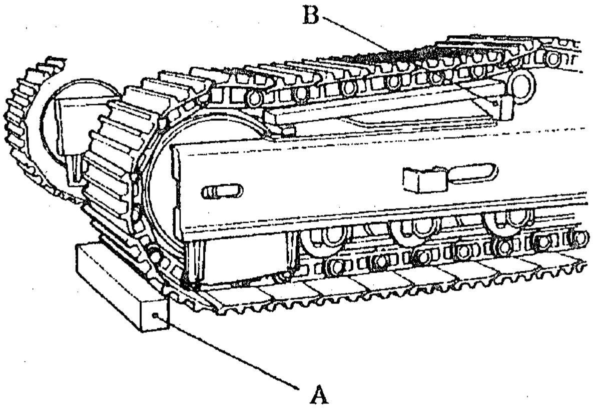


Fig. 11

3) Following the procedure opposite to that for removal, install the collar (7), join the track link, and hammer in the master pin (6).

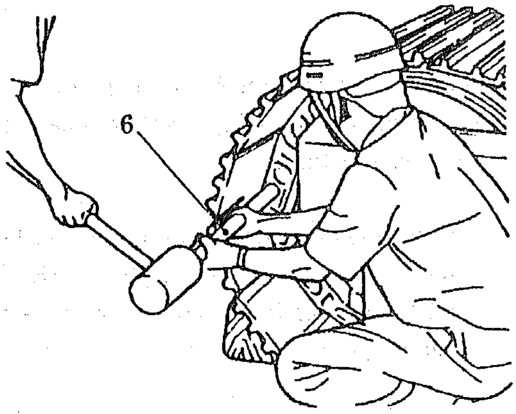


Fig. 12

☞ Check the holes in the track link in the joint and the O.D. of the master pin. Replace both in case the holes are deformed or worn off too much.

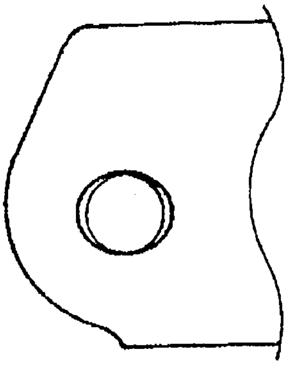


Fig. 13

4) When shoe plate (8) is taken off, attach the shoe plate and tighten shoe bolt (9) and shoe nut (10) to a specified torque.

☞ Specified torque for shoe bolt (9) is 30±3 kgf·m (217±22 ft·lbs).

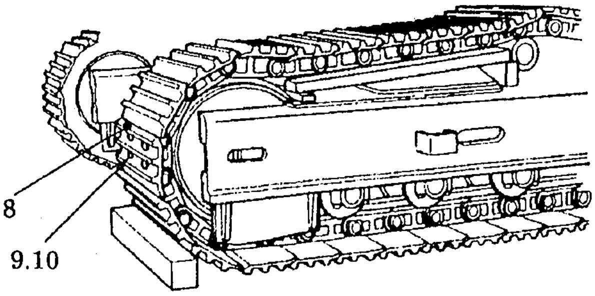


Fig. 14

3.1.3 DISMANTLING THE RUBBER ROLLER

1) Swing the upper frame to a position at right angles to the crawler, bring the bucket down to the ground and fold the boom cylinder toward yourself till the machine body takes off the land.

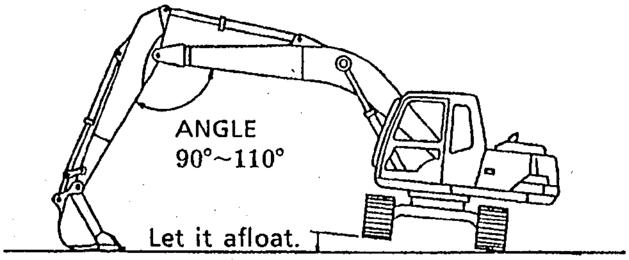


Fig. 15

2) Loosen the nipple for the track spring adjuster, let the grease out of the cylinder and slacken the tension of the shoe.

⚠ • When loosening the adjuster nipple, do not loosen it more than one turn.
• If grease is hard to come out, move the machine back and forth.

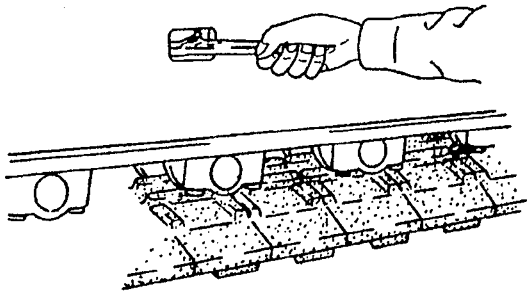


Fig. 16

3) Allow an iron pipe to catch the rubber crawler, rotate the sprocket in the backward direction and when the rubber crawler floats from the idler by means of an iron pipe, slide it sideways and remove it.

☞ After making certain that the inside grease is out completely, turn the sprocket.

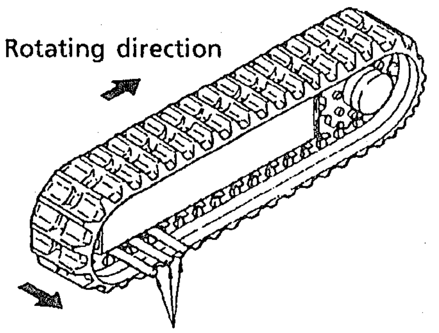


Fig. 17

3.1.4 MOUNTING THE RUBBER CRAWLER

1) Engage the rubber in the sprocket and hang it in the idler.
2) Rotate the sprocket backward and push in the rubber crawler.
3) Get an iron pipe entangled in the rubber crawler, rotate the sprocket again and catch the rubber roller in the idler firmly.

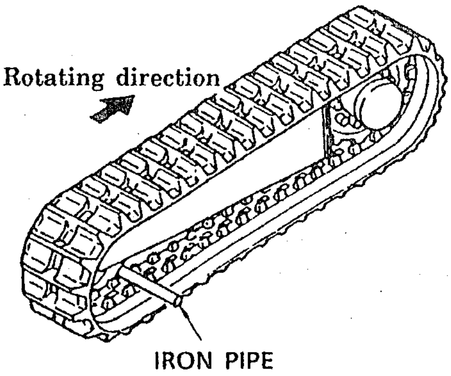
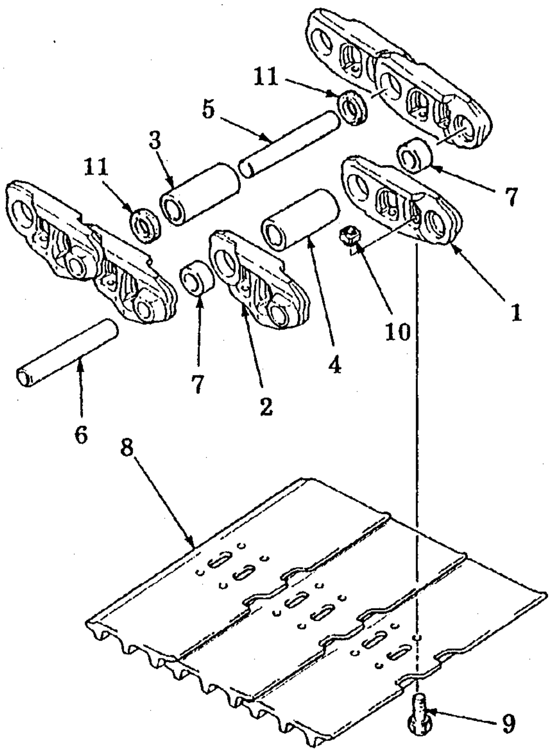


Fig. 18

4) After making certain that the rubber crawler, the sprocket and the idler are engaged and tensioned properly, bring the machine body down to the ground.

3.2 CONSTRUCTION

(1) Standard specification



(2) Rubber crawler specification

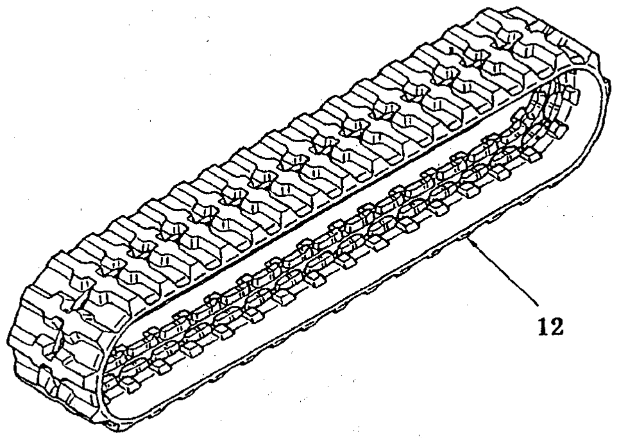


Fig. 19

No.	NAME	Q' ty		No.	NAME	Q' ty	
		Standard	Rubber			Standard	Rubber
1	TRACK LINK (R,H)	38	–	7	COLLAR	4	–
2	TRACK LINK (L,H)	38	–	8	SHOE PLATE	76	–
3	TRACK BUSHING	37	–	9	SHOE BOLT	304	–
4	MASTER BUSHING	2	–	10	SHOE NUT	304	–
5	TRACK PIN	37	–	11	SEAL	74	–
6	MASTER PIN	1	–	12	RUBBER CRAWLER	–	2

4. UPPER ROLLER

4.1 REMOVAL AND INSTALLATION PROCEDURES

4.1.1 REMOVING UPPER ROLLER

Remove capscrew (G) at the bracket of the upper roller.

4.1.2 INSTALLING UPPER ROLLER

1) Tighten capscrew (G) of the bracket to the specified torque.

☞ For bolt(G) tightening torque, see "Maintenance Standards."

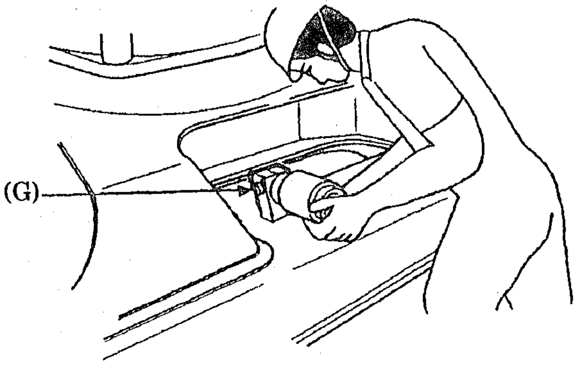


Fig. 20

4.2 PRINCIPAL SPECIFICATIONS

Specification	
Engine oil volume (API classification CD class #30)	20 cc (1.22 cuin)
Weight	4.4 kg (10 lbs)

4.3 CONSTRUCTION

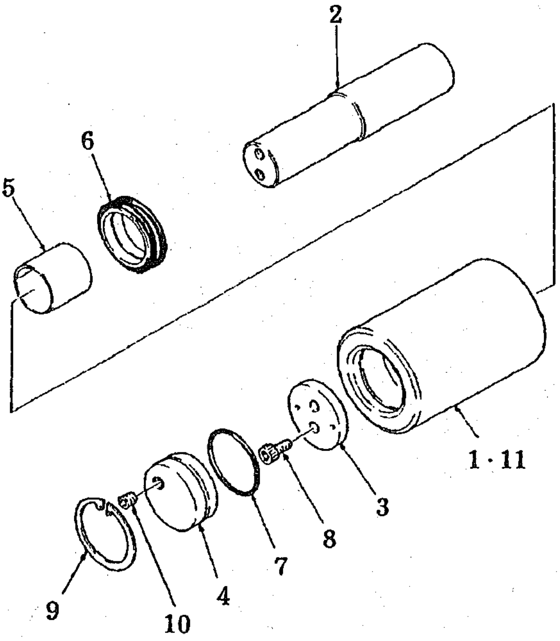


Fig. 21

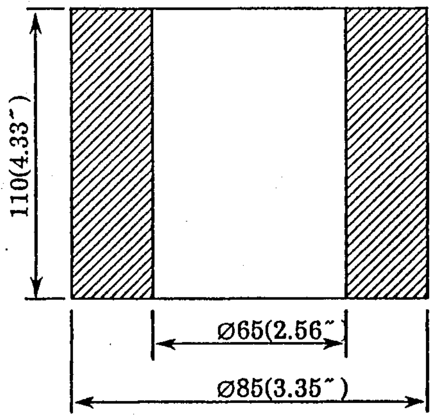
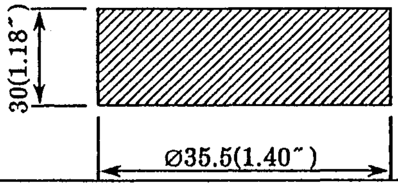
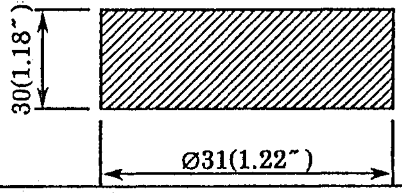
No.	NAME	Q' ty		No.	NAME	Q' ty	
		Standard	Rubber			Standard	Rubber
1	ROLLER	1	–	7	O RING	1	←
2	SHAFT	1	←	8	SOCKET BOLT	2	←
3	PLATE	1	←	9	SNAP RING	1	←
4	COVER	1	←	10	PLUG	1	←
5	BUSHING	1	←	11	ROLLER	–	1
6	FLOATING SEAL	1	←				

4.4 DISASSEMBLY AND ASSEMBLY

4.4.1 TOOLS

Prepare the following tools for disassembly and assembly.

Table 2

Symbol	Tools	An area on which a tool is used	Remarks
a	Driver		
b	Plier lineman		
c	Prier		
d	Spanner		
e	Press		20 ton class (44,000 lbs)
f	Upper roller receiver jig		
g	Bushing drawing jig		
g'	Pin drawing jig		
h	Torque wrench	Socket bolt (9)	3 ~ 10 kgf·m (22~72 ft·lbs)
i	Hammer	Cover (5)	Sliding Hammer
j	Three Bond	Socket bolt (9)	1360K
k	Allen key spanner	Plug (11)	Width a cross flats 6mm (0.24")
l		Socket bolt (9)	Width a cross flats 6mm (0.24")
m	Engine oil		API classification CD class #30
n	Seal tape	Plug (11)	1 roll

4.4.2 DISASSEMBLING THE UPPER ROLLER

The numbers in parentheses following each part name in the text correspond to those in Figure 18.

1) Remove the plug (11), and drain out the oil.

2) Place the upper roller (1) on the support jig (F), and with the pliers (c), remove the snap ring (10) from the upper roller (1).

3) Using the sliding hammer (i), remove the cover (5).

4) Remove the O ring (8) from the cover (5).

5) Remove the hex socket head bolts (9) to remove the plate (4) from the upper roller (1).

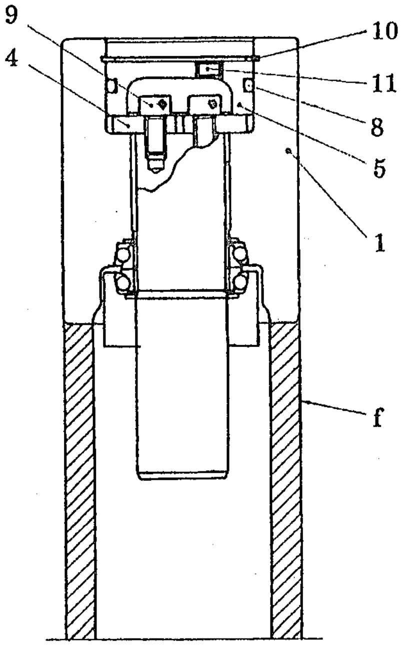


Fig. 22

6) Out the pusher Jig (g') on the shaft (2), and using the press (e) or a hammer, force out the shaft (2) and the collar (3).

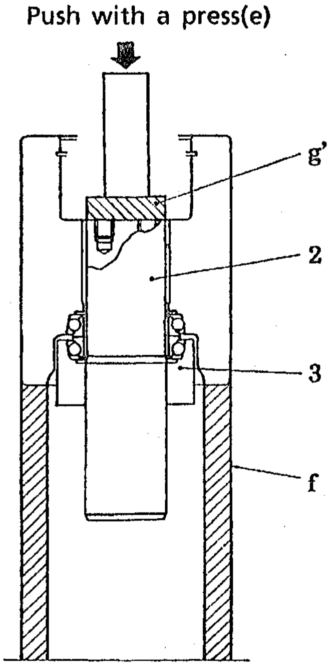


Fig. 23

7) Remove the floating seal (7) from the upper roller (1).

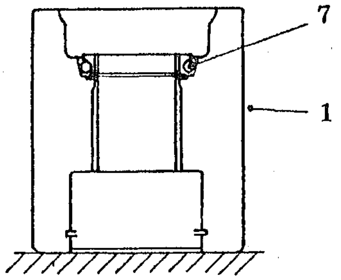


Fig. 24

8) Remove the floating seal (7) from the collar (3).

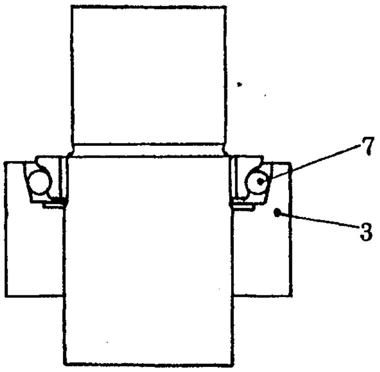


Fig. 25

9) To remove the bushing, place the upper roller (1) on the support, put the pusher jig (g) on the bushing (6), and force out the bushing with the press (e).

10) Parts (2) and (3) are press-fit together, and so cannot be disassembled.

Push with a press(e)

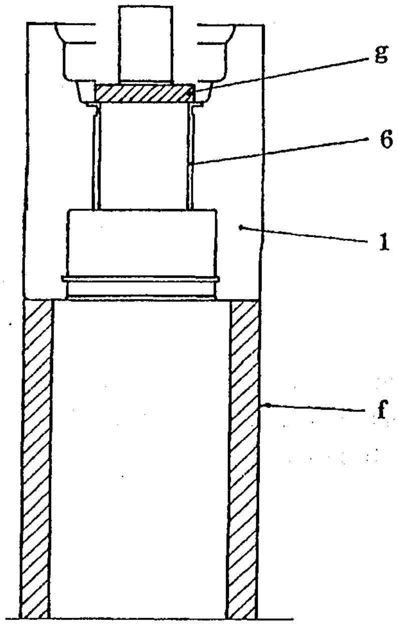


Fig. 26

4.4.3 INSPECTION AFTER DISASSEMBLY

1) No scratches or rusts on the surface of the floating seal.
2) Wear on roller to be within the allowable limit.
3) Wear on shaft and bushing to be within the allowable limit.
4) Interference of the bushing and the roller to be within the allowable limit.
5) Clearance (roller side-clearance) of the bushing and the collar to be within the allowable limit.

4.4.4 ASSEMBLY UPPER ROLLER

Assembly order is reverse one of disassembly.
The numbers in parentheses following each part name in the text correspond to those in Figure 18.

1) Place the upper roller (1) on the upper roller support jig (f), install the bushing (6) in the upper roller (1), put the bushing pusher jig (g) on the bushing (6), and force-fit the bushing into the upper roller using the press (e).

☞ In the event that the press-fitting attempt fails, do not try to use the same bushing again.

Push with a press(e)

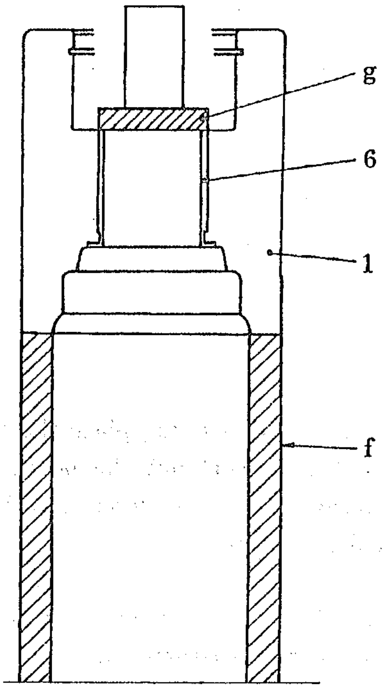


Fig. 27

2) Install the floating seal (7) in the collar (3).

☞ Apply a thin coat of engine oil to the sealing face of the floating seal (7) before installation.

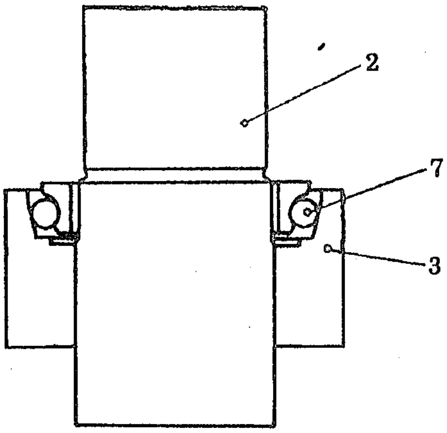


Fig. 28

3) Install the floating seal (7) in the upper roller (1).

☞ Apply a thin coat of engine oil to the sealing face of the floating seat (7) before installation.

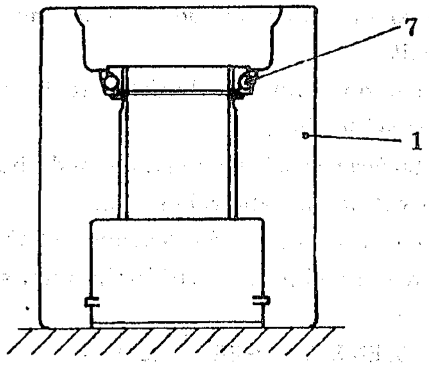


Fig. 29

4) Install the shaft (2) in the upper roller (1) using the press (e).

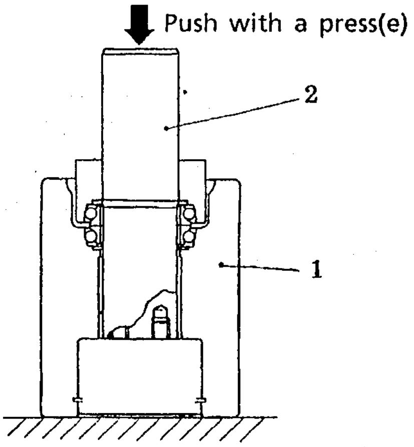


Fig. 30

5) Place the upper roller (1) on the upper roller support jig (f), apply Three Bond 1360K to the threads of the hex socket head bolts (9), and tighten the plate (4) with the hex socket head bolts (9) to a specified torque of 3.4±0.35 kgf·m (25±3 ft·lbs).

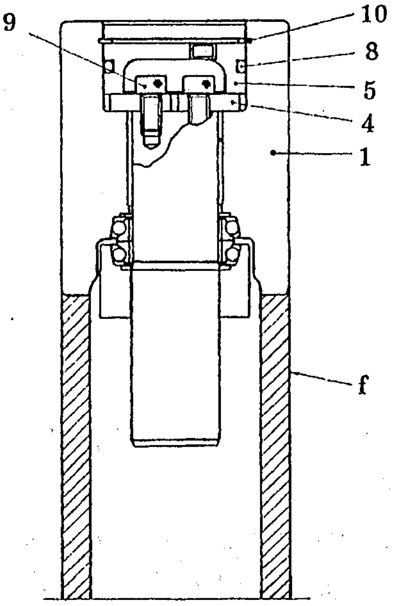


Fig. 31

6) Apply a thin coat of grease to the O ring (8), and install it on the cover (5).

7) Force-fit the cover (5) to the upper roller (1) using the press.

8) Install the snap ring (10) in the upper roller (1) using the pliers (c).

9) Remove the filler plug (11) form the cover (5), and add 20 cc (1.22 cuin) of engine oil (m) (grade CD, #30, API classification).

10) Wind sealing tape (n) around the plug (11), install the plug in the cover (5), and then tighten the plug with the hex key (k).

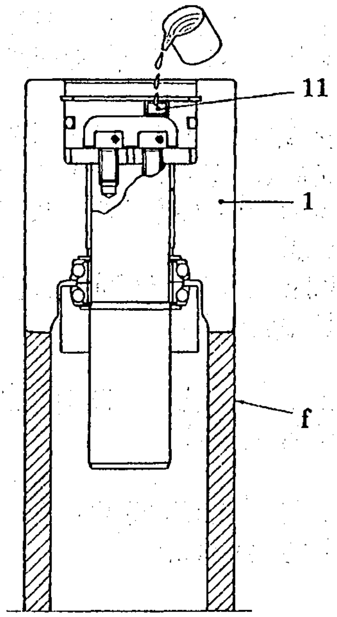


Fig. 32

4.4.5 INSPECTION AFTER REASSEMBLY

1) Confirm that there are no oil leaks around the floating seal (7) and the filler plug (11).

2) Manually confirm that the upper roller (1) turns smoothly.
(Some resistance will be felt)

5. LOWER ROLLER

5.1 REMOVAL AND INSTALLATION PROCEDURES

5.1.1 REMOVING THE LOWER ROLLER

1) Loosen track tension, and raise the machine about 30 cm (11.8 in) off the ground, as shown in Figure 30.

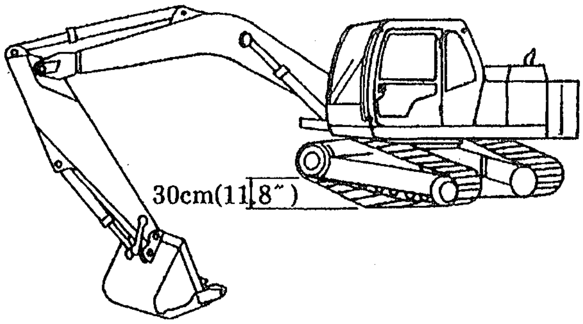


Fig. 33

2) Put a wooden block under the lower roller, and loosen the four roller mounting bolts.

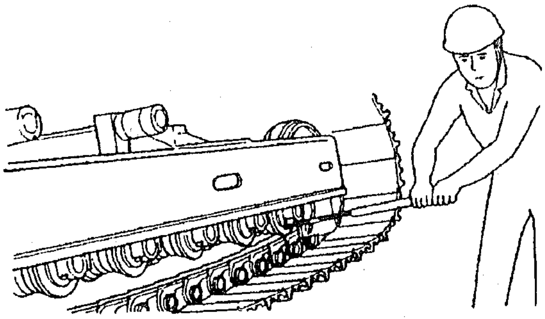


Fig. 34

3) Remove the bolts, and pull out the lower roller.

5.1.2 INSTALLING THE LOWER ROLLER

1) Apply Three Bond 1305 to the threads of the lower roller mounting bolts.
2) Align the bolt holes in the lower frame and the lower roller (1), and temporarily tighten the bolts using a small ratchet wrench.

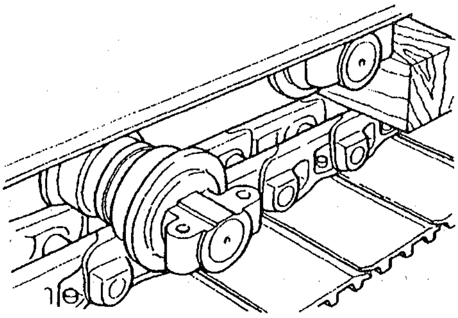


Fig. 35

☞ ● If any abnormal condition, such as excessive resistance by a bolt, is felt, remove the bolt once and inspect the threads.

● Do not use an impact wrench for temporary tightening.

3) Tighten the bolts to the specified torque with a torque wrench.

☞ For bolt tightening torque, see "Maintenance Standards ".

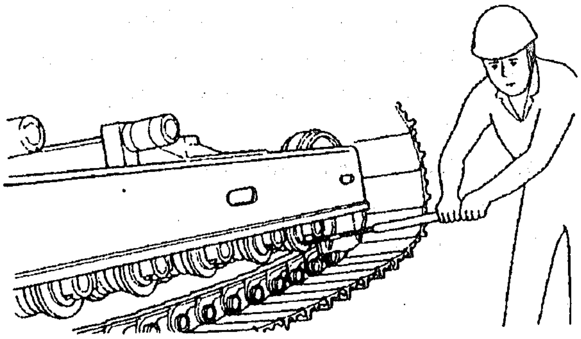


Fig. 36

5.2 PRINCIPAL SPECIFICATIONS

	Specification
Engine oil volume (API classification CD class #30)	90 cc (5.49 cuin)
Weight	13.7 kg (30 lbs)

5.3 CONSTRUCTION

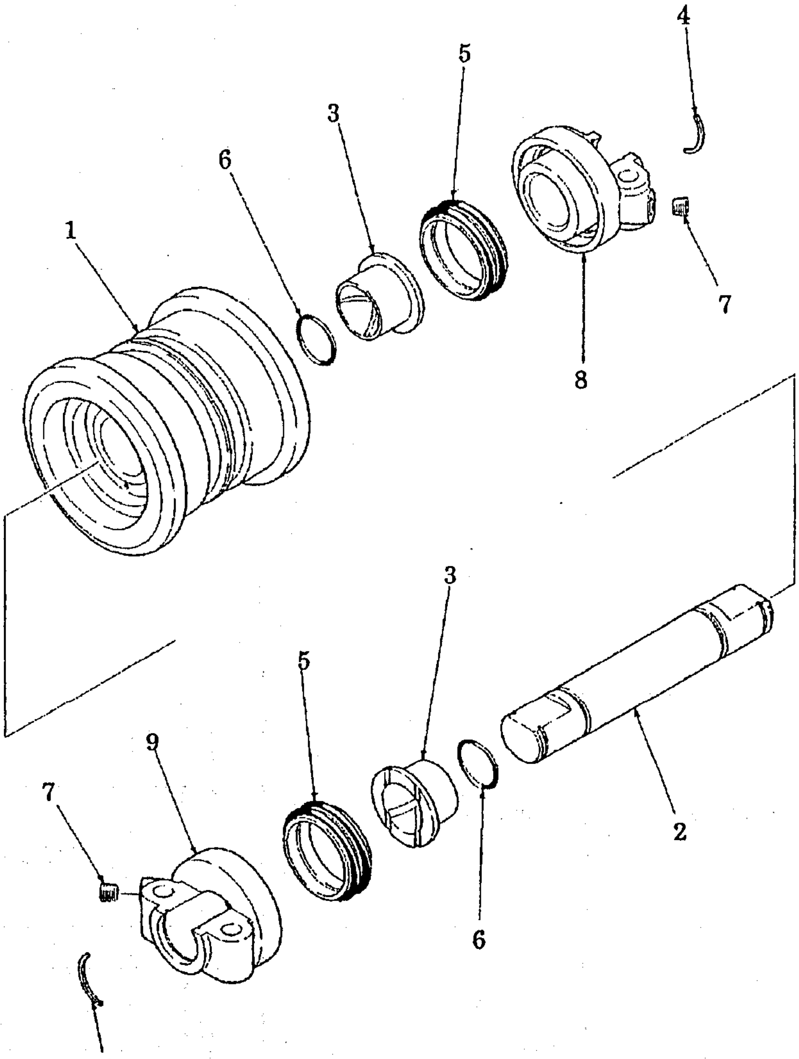


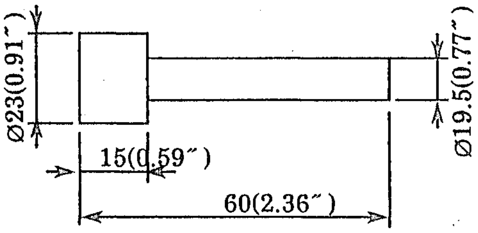
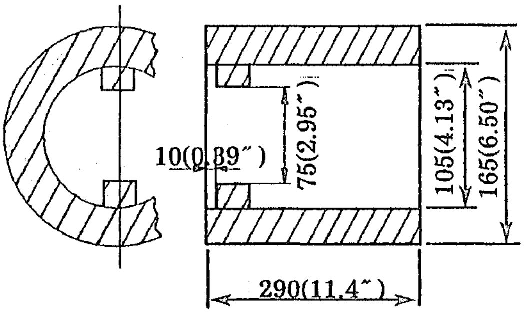
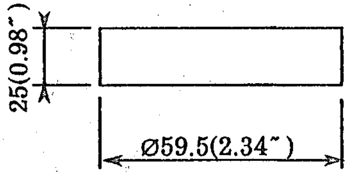
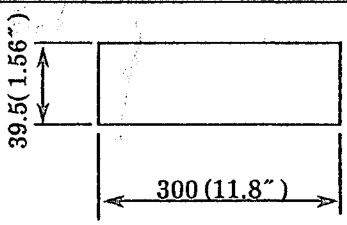
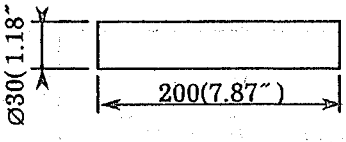
Fig. 37

No.	NAME	Q' ty		No.	NAME	Q' ty	
		Standard	Rubber			Standard	Rubber
1	LOWER ROLLER	1	←	6	O RING	2	←
2	SHAFT	1	←	7	PLUG	2	←
3	BUSHING	2	←	8	COLLAR	1	←
4	LOCK RING	2	←	9	COLLAR	1	←
5	FLOATING SEAL	2	←				

5.4 DISASSEMBLY AND ASSEMBLY

5.4.1 TOOLS.

Prepare the following tools for disassembly and assembly.

Symbol	Tools	An area on which a tool is used		Remarks
a	Hammer	Collar	(8)(9)	
b	Press	Shaft	(2)	20 ton class (44,000 lbs)
		Bushing	(3)	
c	Lock ring drawing jig	Collar	(8)(9)	 Ø23(0.91") 15(0.59") 60(2.36") Ø19.5(0.77")
d	Lower roller receiver jig	Lower roller	(1)	 10(0.39") 75(2.95") 105(4.13") 165(6.50") 290(11.4")
e	Bushing fixing jig	Bushing	(3)	 25(0.98") Ø59.5(2.34")
f	Shaft extruding jig	Shaft	(2)	 39.5(1.56") 300(11.8")
g	Bushing extruding jig	Bushing	(3)	 Ø30(1.18") 200(7.87")
h	Chisel	Lock ring	(4)	
i	Molybdenum disulfide grease			
j	Seal tape			1 roll
k	Engine oil			API classification CD class #30

5.4 DISASSEMBLY

The numbers in parentheses following each part name in the text correspond to those in Figure 34.

5.4.1 DISASSEMBLING THE LOWER ROLLER

1) Remove the plug (7), and drain out the oil.

2) Insert the lock link puller jig (c) into the collar mounting cap screw hole in the collars (8, 9), rotate the collar by tapping the jig with a hammer (a), and drive out the lock link (4) using a chisel (f) and hammer (a).

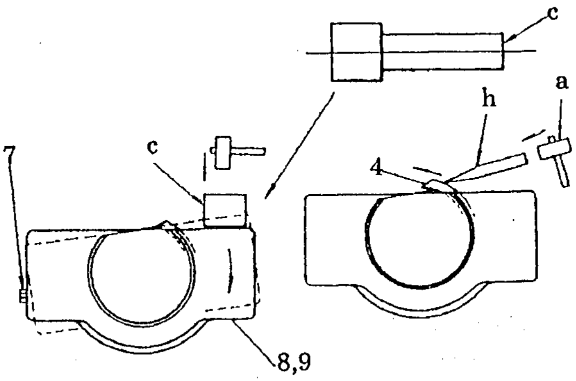


Fig. 39

3) Place the lower roller (1) on the support jig (d), put the shaft removal jig (f) on the shaft (2), and force out the shaft with a press or hammer.

☞ Prepare a container to catch the oil flowing out of the lower roller (1).

Push with a press (b).

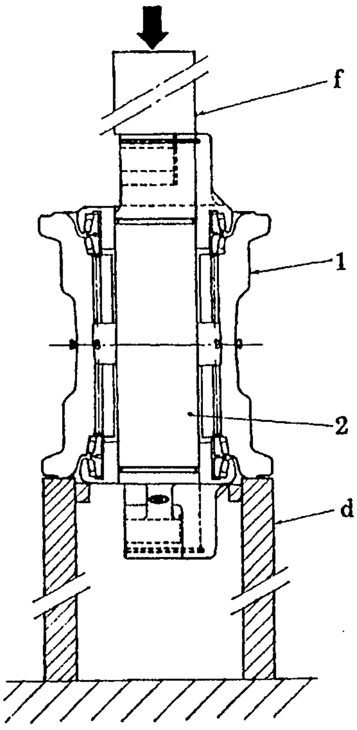


Fig. 39

4) Remove the floating seal (5) from the collars (8,9).

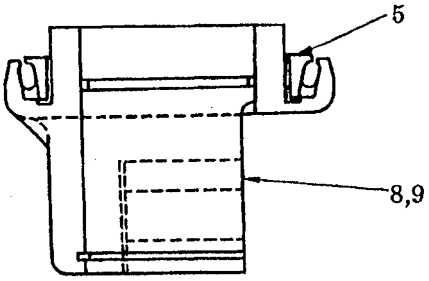


Fig. 40

5) Remove the floating seal (5) from the lower roller (1).

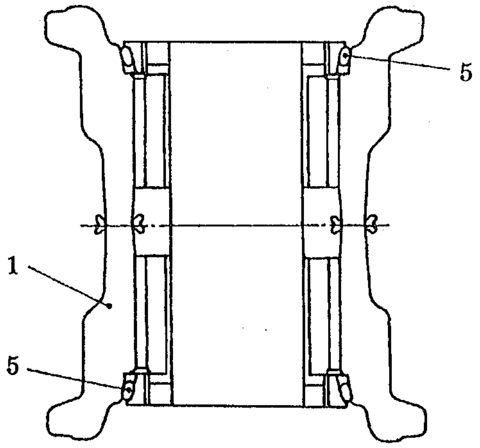


Fig. 41

6) Place the lower roller (1) on the lower roller support jig (d), put the bushing removal jig (g) on the bushing (3), and force out the bushing by tapping the jig with a hammer (a).

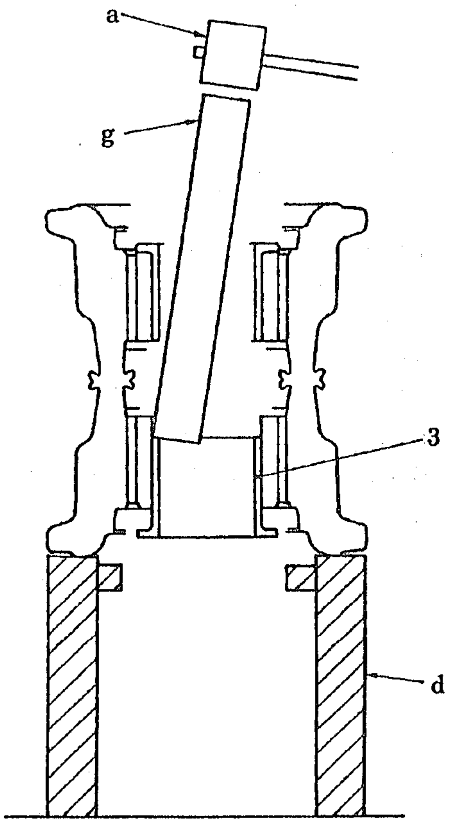


Fig. 42

7) Remove the O ring (6) from the shaft (2).

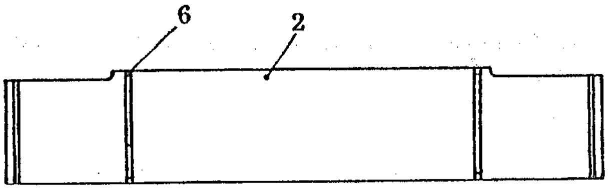


Fig. 43

5.4.2 INSPECTION AFTER DISASSEMBLY

1) Confirm that there is no damage or rust on the sealing face of the floating seal.
2) Confirm that any wear of the roller is within the allowable range.
3) Confirm that any wear of the shaft or bushing is within the allowable range.
4) Confirm that the interference between the bushing and the roller is within the allowable range.
5) Confirm that the clearance between the bushing and the collar (side clearance of the roller)is within the allowable range.

5.4.3 REASSEMBLING THE LOWER ROLLER

The reassembly procedure is the reverse of the order of disassembly.

The numbers in parentheses following each part name in the text correspond to those in Figure 34.

1) Apply a thin coat of grease to the O ring (6), and install the O ring on the shaft (2).

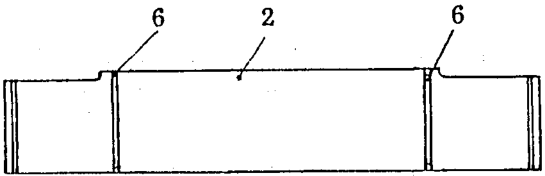


Fig. 44

2) Apply molybdenum disulfide to the part of bushing (3) that is to be press-fit, put the bushing press-fit jig (e) on the bushing, and force-fit the bushing with the press (b).

Push with a press (b).

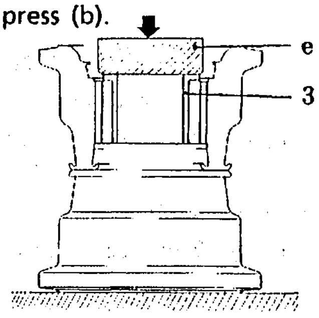


Fig. 45

3) Fix collar (9) to lower roller (1), mount lower roller support (d) and insert shaft (2) by means of press (b).

Push with a press (b).

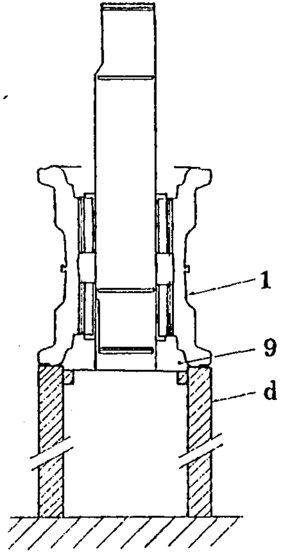


Fig. 46

4) Install the floating seal (5) in the lower roller (1).

5) Install the floating seal (5) in the collars (8,9).

6) Install the collar (8) in the lower roller (1).

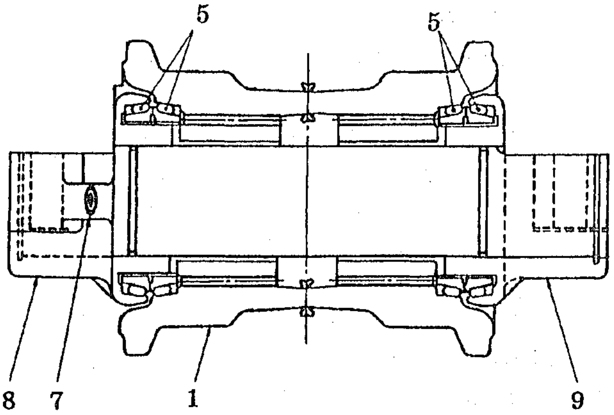


Fig. 47

7) Drive the lock link (4) onto the collars (8, 9).

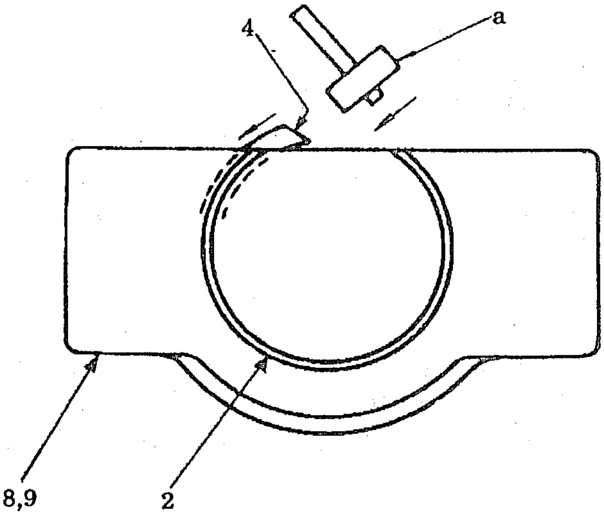


Fig. 48

8) Remove the plug (7), and add 90 cc (5.49 cuin) of engine oil (k) (#30, grade CD, API classification). After filling, wind sealing tape (j) around the plug (7), and tighten the plug with a hex key.

5.4.4 INSPECTION AFTER REASSEMBLY

1) Confirm that there are no oil leaks around the floating seal (5) and the plug (7).

2) Manually confirm that the lower roller (1) turns smoothly. (Some resistance will be felt)

6. IDLER · (TRACK SPRING)

6.1 REMOVAL AND INSTALLATION PROCEDURES

6.1.1 REMOVING THE IDLER AND THE TRACK SPRING

1) Remove the track.

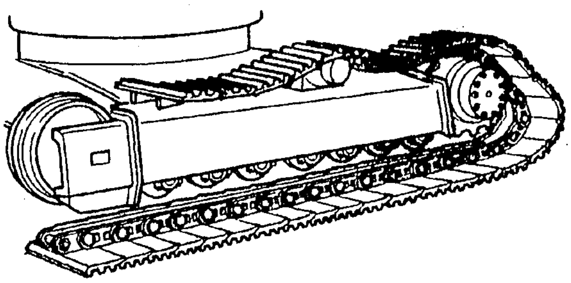


Fig. 49

2) Pass a wire rope through the hole (s) in the track spring bracket, lift the bracket, and using a lever bar, push the bracket out of the track frame.

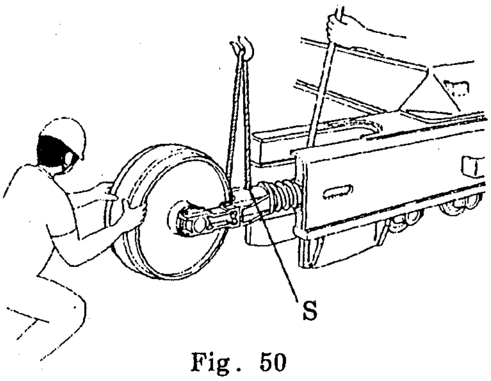


Fig. 50

6.1.2 INSTALLING THE IDLER AND THE TRACK SPRING

1) Pass a wire rope through the hole (S) in the track spring bracket, lift the bracket, then fit and push the slide block into the slide groove in the track frame.

☞ Confirm that the boss at the piston end of the track spring is in the track frame hole.

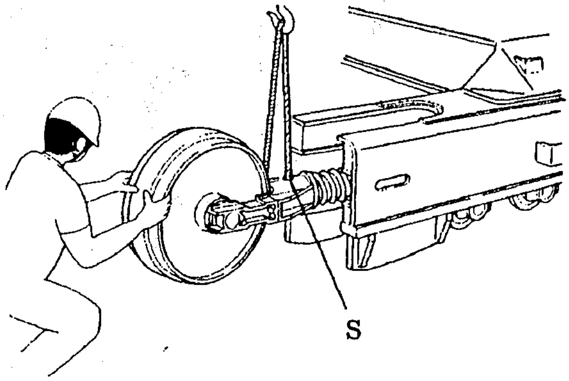


Fig. 51

2) Install the track.

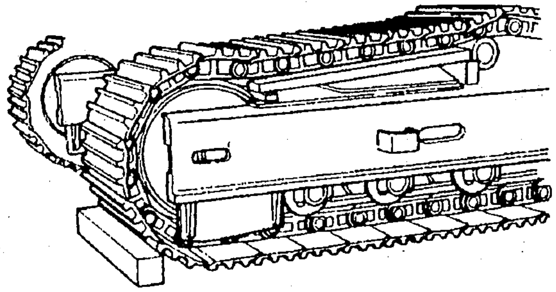


Fig. 52

6.2 PRINCIPAL SPECIFICATIONS

Specification	
Engine oil volume (API classification CD class #30)	150~160 cc (9.15~9.76 cuin)
Weight	43 kg (95 lbs) Standard 44.8 kg (99 lbs) Rubber

6.3 CONSTRUCTION

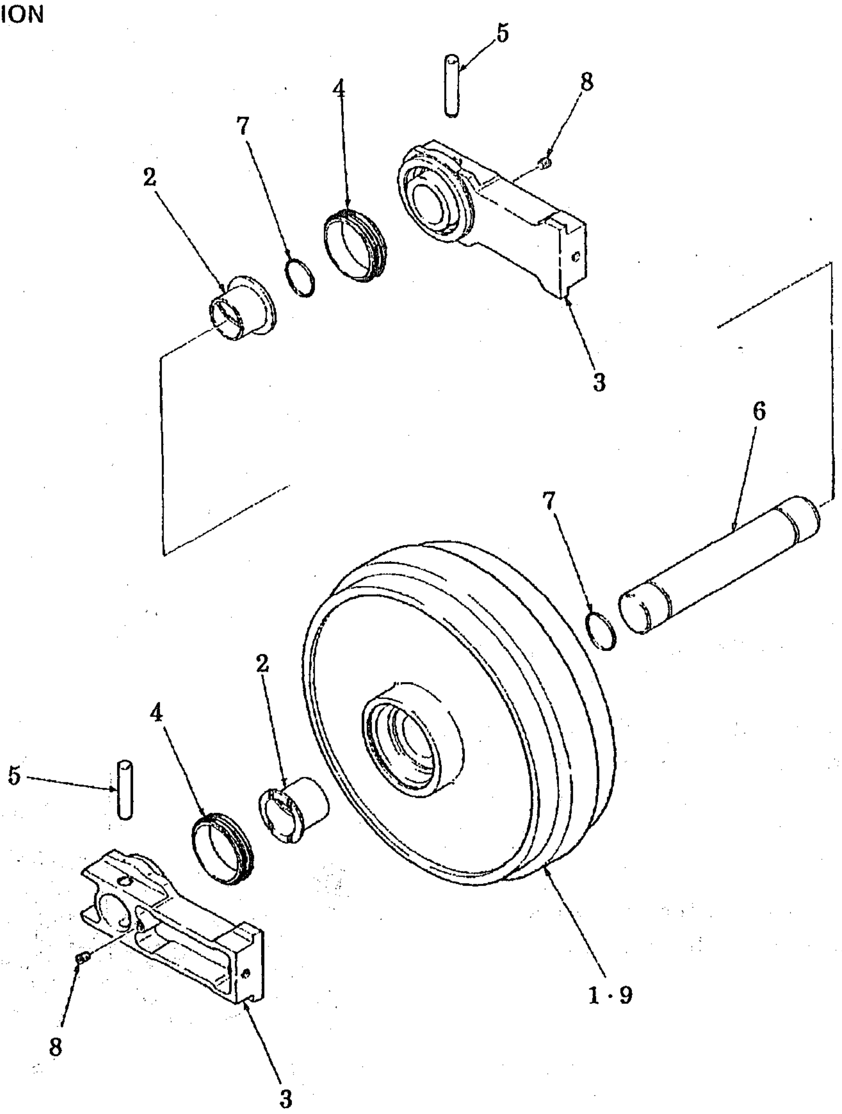


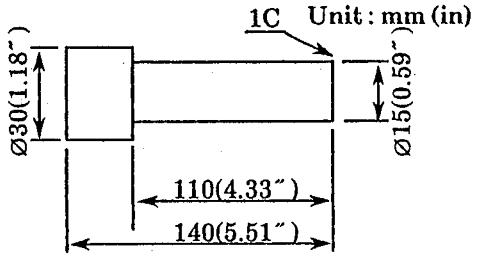
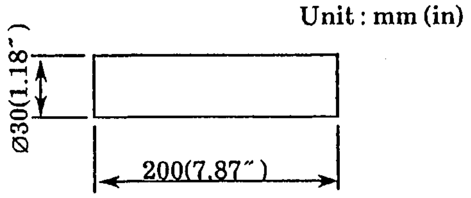
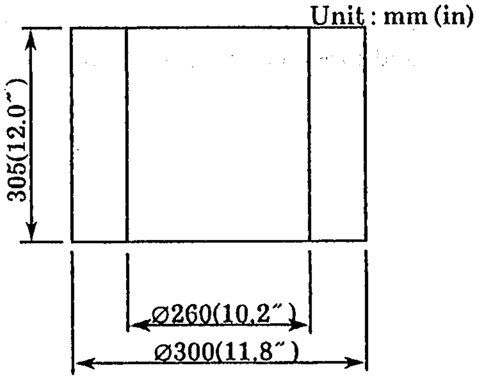
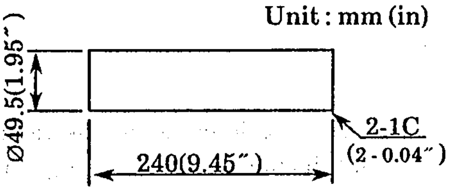
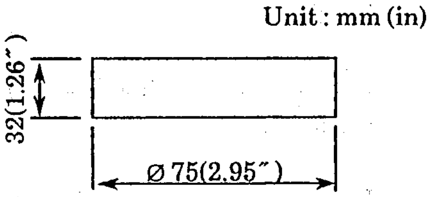
Fig. 53

No.	NAME	Q'ty		No.	NAME	Q'ty	
		Standard	Rubber			Standard	Rubber
1	IDLER	1	–	6	SHAFT	1	←
2	BUSHING	2	←	7	O RING	2	←
3	SLIDE BLOCK	2	←	8	PLUG	2	←
4	FLOATING SEAL	2	←	9	IDLER	–	1
5	PIN	2	←				

6.4 DISASSEMBLY AND ASSEMBLY

6.4.1 TOOLS.

Prepare the following tools for disassembly and assembly.

<table>
<tr><th>Symbol</th><th>Tools</th><th>An area on which a tool is used</th><th></th><th>Remarks</th></tr>
<tr><td>a</td><td>Press</td><td></td><td></td><td>20 ton (44,000 lbs)</td></tr>
<tr><td>b</td><td>Grease gun</td><td></td><td></td><td></td></tr>
<tr><td>c</td><td>Torque wrench</td><td></td><td></td><td>60kgf · m (433 ft · lbs)</td></tr>
<tr><td>d</td><td>Pin drawing jig</td><td>Pin</td><td></td><td>

1C
Unit : mm (in)
Ø30(1.18")
Ø15(0.59")
110(4.33")
140(5.51")
</td></tr>
<tr><td>e</td><td>Bushing drawing jig</td><td>Bushing</td><td>(2)</td><td>

Unit : mm (in)
Ø30(1.18")
200(7.87")
</td></tr>
<tr><td>f</td><td>Idler receiver jig</td><td>Idler</td><td>(1)</td><td>

Unit : mm (in)
305(12.0")
Ø260(10.2")
Ø300(11.8")
</td></tr>
<tr><td>g</td><td>Shaft extruding jig</td><td>Shaft</td><td>(6)</td><td>

Unit : mm (in)
Ø49.5(1.95")
2-1C
(2 - 0.04")
240(9.45")
</td></tr>
<tr><td>h</td><td>Bushing fixing jig</td><td>Bushing</td><td>(2)</td><td>

Unit : mm (in)
32(1.26")
Ø 75(2.95")
</td></tr>
<tr><td>i</td><td>Dry ice</td><td>Bushing</td><td>(2)</td><td></td></tr>
<tr><td>j</td><td>Engine oil</td><td></td><td></td><td>API classification CD class#30</td></tr>
<tr><td>k</td><td>Hammer</td><td></td><td></td><td></td></tr>
</table>

6.5 DISASSEMBLY

The numbers in parentheses following each part name in the text correspond to those in Figure 50.

6.5.1 DISASSEMBLING THE IDLER

1) Remove the cap screws, and remove the track spring.

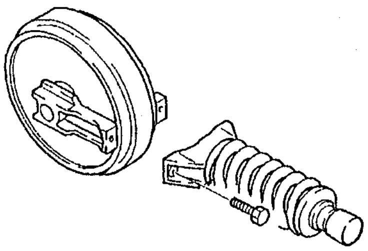


Fig. 54

2) Put the pin removal jig (d) on the pin (5), and drive out the pin by lightly tapping the jig with a hammer (k).

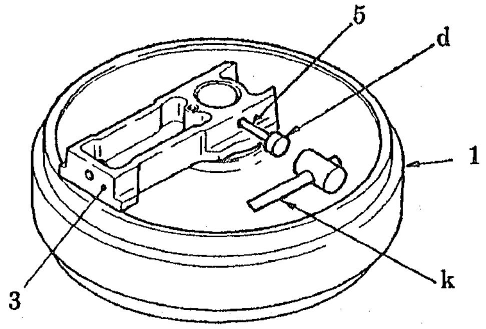


Fig. 55

3) Place the idler (1) on the idler support jig (f), put the shaft removal jig (g) on the shaft (6), and force out the shaft using the press (a).

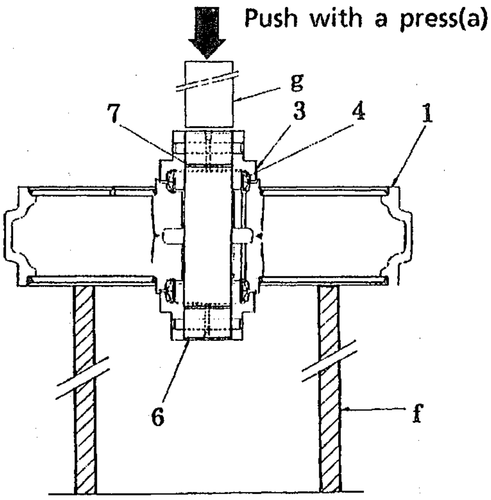


Fig. 56

4) Place the idler (1) on the idler support jig (f), put the bushing removal jig (e) on the bushing (2), and drive out the bushing by lightly tapping the jig.

5) Remove the floating seal (4) from the slide block (3).

6) Remove the O ring (7) from the shaft (6).

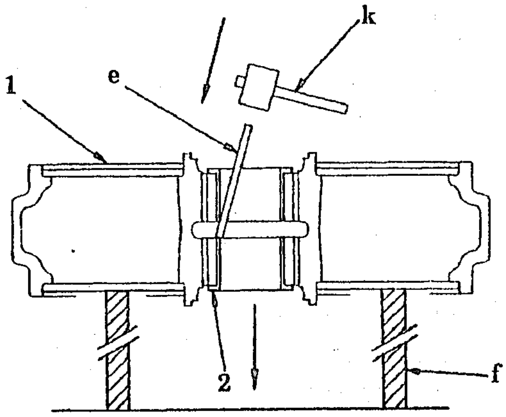


Fig. 57

6.5.2 INSPECTION AFTER DISASSEMBLY

1) Confirm that there is no damage or rust on the sealing face of the floating seal (4).
2) Confirm that any wear of the idler (1) is within the allowable range.
3) Confirm that any wear of the shaft (6) or bushing (2) is within the allowable range.
4) Confirm that the clearance between the bushing (2) and slide block (3) (side clearance) is within the allowable range.

6.5.3 REASSEMBLING THE IDLER

The reassembly procedure is the reverse of the order of disassembly.

The numbers in parentheses following each part name in the text correspond to those in Figure 50.

1) Put the bushing press–fit jig (h) on the bushing (2) of the front idler (1), and force–fit the bushing with the press (a).

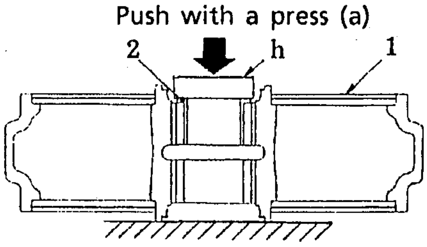


Fig. 58

2) Apply a thin coat of grease to the O ring (7), and install the O ring on the shaft (6).
3) Insert the shaft (6) into the slide block (3), and drive in the pin (5).

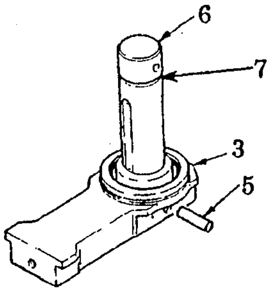


Fig. 59

4) Install floating seals in the slide block (3) and the idler (1).
5) Install the shaft (6) in the idler (1) (with floating seal installed).

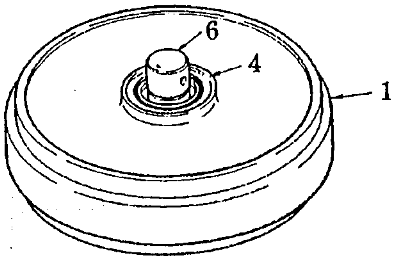


Fig. 60

6) Install the slide block (3) in which the floating seal (4) has been installed.
7) Drive in the pin (5) with a hammer (k)
8) Take off plug (8) and fill 150~160cc (9.15~9.76 cuin)of engine oil (j) (API Class CD Grade 30).

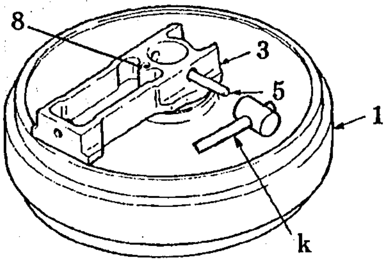
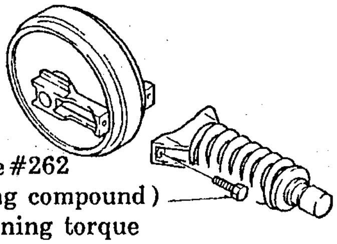


Fig. 61

6.5.4 INSPECTION AFTER REASSEMBLY

1) Confirm that there are no oil leaks around the floating seal (4) and the plug (8).
2) Reassemble the idler assembly and the track spring.

   After reassembly, manually confirm that the idler (1) rotates (to the extent you can rotate it despite resistance).



Loctite #262
(locking compound)
Tightening torque
11.7±1.2kgf·m (85±9ft·lbs)

Fig. 62

7. TRACK TENSION ASSEMBLY

7.1 PRINCIPAL SPECIFICATIONS

	Specification
Set load	4,160±250kg (9170±550 lbs)
Weight	26kg (57 lbs)

7.2 CONSTRUCTION

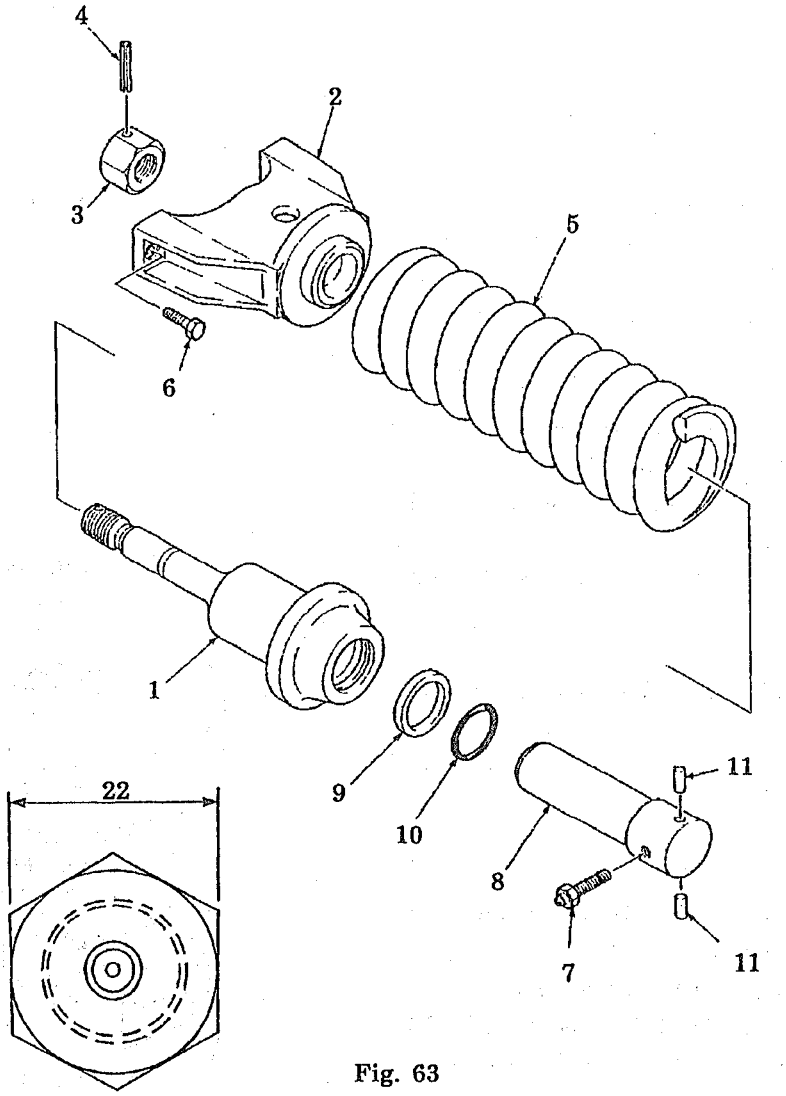


Fig. 63

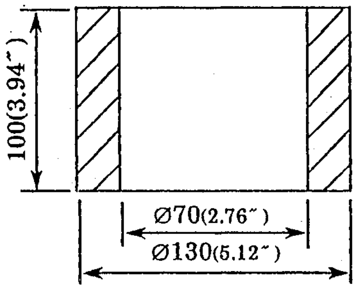
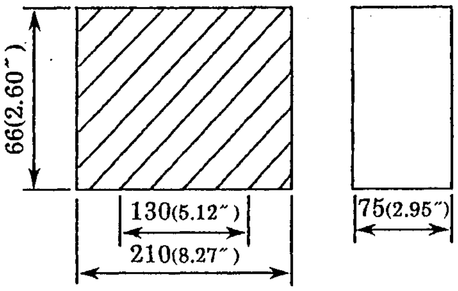
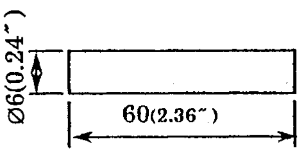
Detail of the hex. head of grease nipple(7)

No.	NAME	Q' ty	No.	NAME	Q' ty
1	GREASE CYLINDER	1	7	GREASE NIPPLE	1
2	BRACKET	1	8	PISTON	1
3	NUT	1	9	OIL SEAL	1
4	SPRING PIN	1	10	O RING	1
5	SPRING	1	11	PIN	2
6	CAPSCREW	2			

7.3 DISASSEMBLY AND ASSEMBLY

7.3.1 TOOLS

Prepare the following tools for disassembly and assembly.

Symbol	Tools	An area on which a tool is used	Remarks
a	Press		20ton (44000 lbs)
b	Torque wrench		30kgf · m (217 ft · lbs)
c	Track tension receiver jig	Grease cylinder(1)	Unit : mm (in)  100(3.94") Ø70(2.76") Ø130(5.12")
d	Bracket holding jig	Bracket (2)	Unit : mm (in)  66(2.60") 130(5.12") 210(8.27") 75(2.95")
e	Split pin drawing jig	Split pin (4)	Unit : mm (in)  Ø6(0.24") 60(2.36")
f	Hammer		
g	Grease		
h	Seal tape		1roll

7.3.2 DISASSEMBLING THE TRACK TENSION ASSEMBLY

The numbers in parentheses following each part name in the test correspond to those in Figure 60.

1) Remove the grease nipple (7) from the piston (8)

2) Pull the piston (8) from the grease cylinder (1).

3) Remove the oil seal (9) and the O ring (10) from the grease cylinder (1).

4) Place the track tension assembly on the track tension assembly support jig (c), put the bracket retainer jig (d) on the bracket (2), compress the spring (5) using the press (a), and remove the spring pin (4).

⚠ Take care not to let the press (a) off the spring during this step.

5) Remove the nut (3).

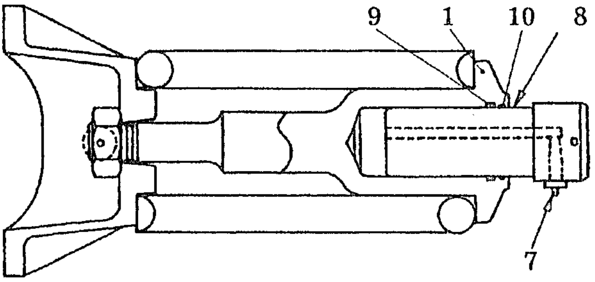


Fig. 64

Push with a press (a)

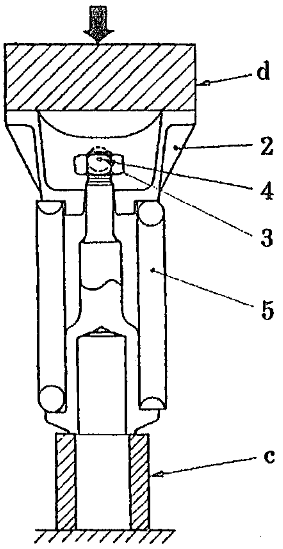


Fig. 65

6) Remove the press (a) slowly, then remove the spring (5) and the bracket (2).

7.3.3 INSPECTION AFTER DISASSEMBLY

1) Confirm that there is no damage or rust on the inner surface of the grease cylinder (1).

2) Confirm that there is no damage or rust on the outer circumference of the piston (8).

3) Confirm that the free length of the spring (5) is within the standard range.

PRESS(a)

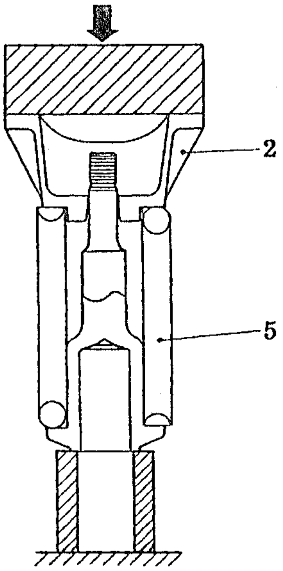


Fig. 66

7.3.4 REASSEMBLING THE TRACK TENSION ASSEMBLY

The reassembly procedure is the reverse of the order of disassembly.

The numbers in parentheses following each part name in the test correspond to those in Figure 60.

1) Install the spring (5) and the bracket (2) on the grease cylinder (1).
2) Place the track tension assembly on the track tension assembly rest jig (c), put the bracket retainer jig (d) on the bracket (2), compress the spring (5) with the press (a), and the tighten nut (3) until the spring pin (4) holes align.

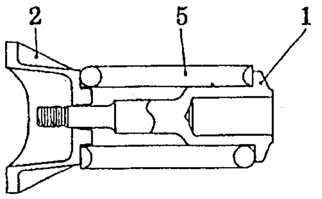


Fig. 67

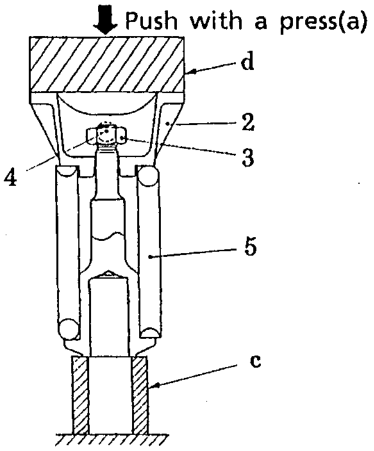


Fig. 68

3) Remove the press (a) slowly, then check the set length of the spring (5).

⚠ Take care not to let the press (a) off the spring during step 2) above.

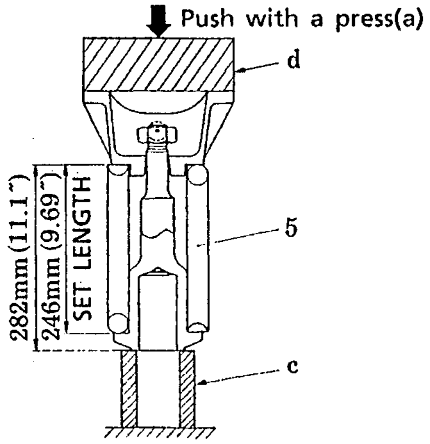


Fig. 69

4) After setting the spring (5) to the specified length, align the hole in the nut (3) with the spring pin hole, and drive the spring pin (4) into the hole using a hammer (f).
5) Install the O ring (10) and oil seal (9) on the grease cylinder (1).
6) Add grease (g) to the grease cylinder (1) ; manually push in the piston (8) so that enough grease escapes from the grease nipple mounting hole to bleed the air.

☞ If the air is not adequately bled, track tension cannot be adjusted properly.

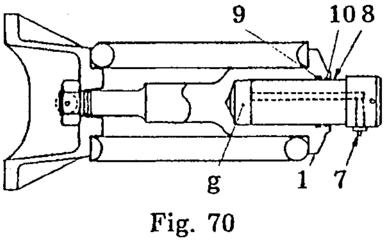


Fig. 70

7) Install the grease nipple (7) in the piston (8).

7.3.5 INSPECTION AFTER INSTALLATION.

1) Confirm that there are no leaks around the oil seal (9) or the grease nipple (7).
2) Confirm that grease can be added through the grease nipple (7).
3) Confirm that the spring is set at the specified length.

8. REMOVAL AND INSTALLATION OF TRAVEL REDUCTION UNIT

8.1 REMOVING THE TRAVEL REDUCTION UNIT

1) Remove the track. Refer to section 3.1.1.

2) Place a wooden block (W) on the track, and place the lower roller on the block to raise the sprocket off the track.

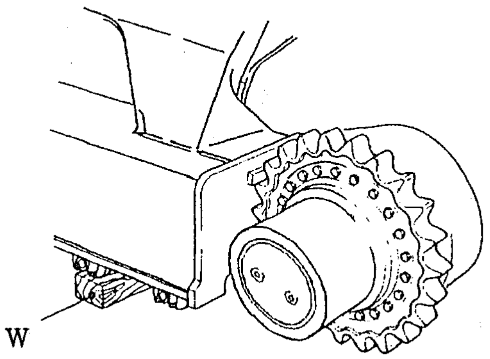


Fig. 71

3) Disconnect the hydraulic pipes leading to the travel motor from the connectors (D) at the travel motor flange face. Plug the pipe ends and ports to prevent the outflow of oil and the entry of foreign matter.

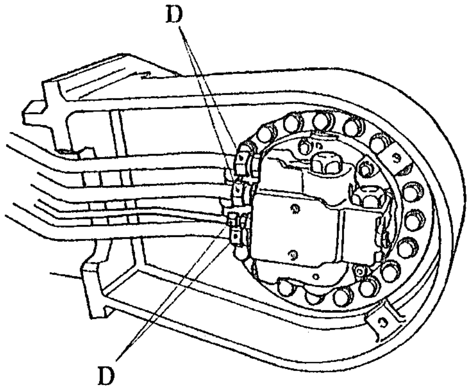


Fig. 72

4) Remove the 12 travel motor mounting cap screws (A), M16, from the lower frame.

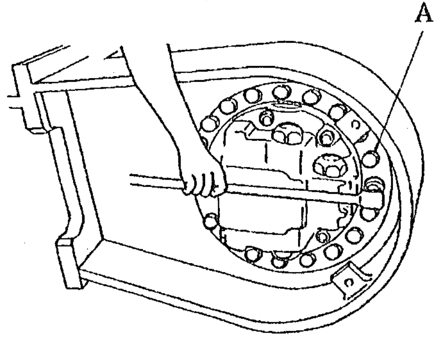


Fig. 73

5) Pass a wire rope around the reduction unit, and lift it. Then, using the pusher bolt holes in the lower frame, force out the reduction unit.

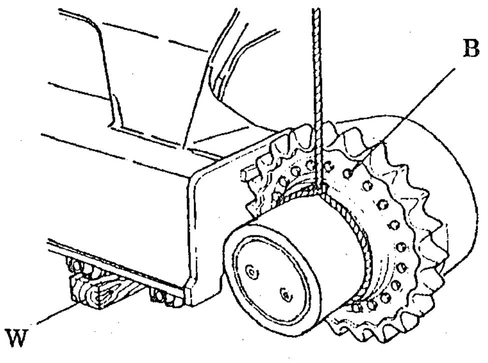


Fig. 74

☞ ◎ Lift the reduction unit as close to the sprocket as possible to maintain balance.
◎ The reduction unit mounting cap screws (A) may be used in the reduction unit pusher bolt holes.
◎ Putting match–marks on the track frame and travel reduction unit will facilitate reassembly.

8.2 INSTALLING THE TRAVEL REDUCTION UNIT

The installation procedure is the reverse of the order of removal.

☞ Carefully check the mating parts of the lower frame and the reduction unit for burrs and contaminants.

1) Pass a wire rope around the travel reduction unit and lift it. Then, install the travel reduction unit on the lower frame.

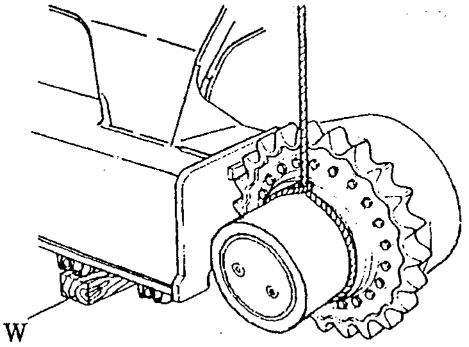


Fig. 75

2) Apply Three Bond 1305 (equivalent to Loctite #262) to the 12 travel motor mounting cap screws (A), and tighten them to the specified torque of 28.5±3 kgf·m (206±22ft·lbs).

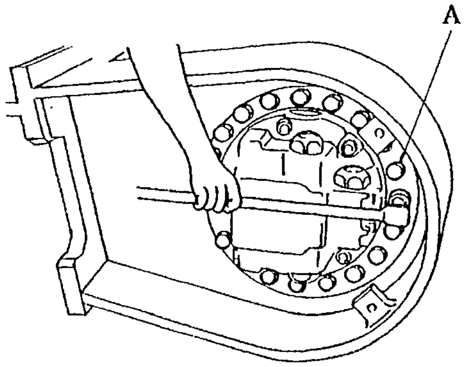


Fig. 76

3) Check the gear oil level in the reduction unit. If necessary, change it or add more.

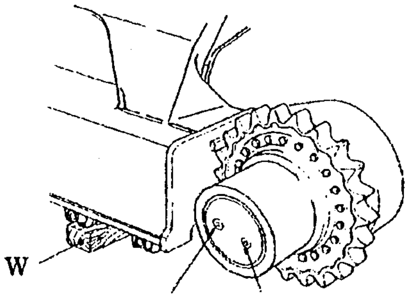


Fig. 77

9. REMOVAL AND INSTALLATION OF SPROCKET

9.1 REMOVING THE SPROCKET

1) Remove the track. Refer to section 3.1.1

2) Place a wooden block (W) on the track, and place the lower frame on the block to raise the sprocket off the track.

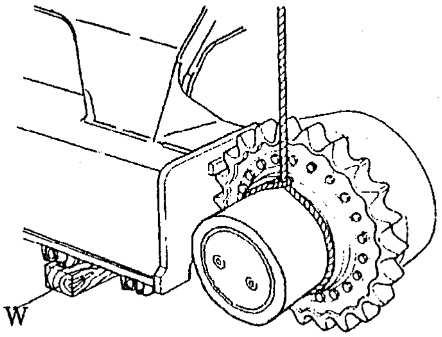


Fig. 78

3) Remove the 12 sprocket mounting cap screws (C), M14, using a box end wrench.

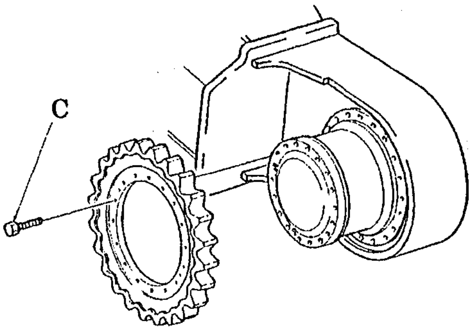


Fig. 79

9.2 INSTALLING THE SPROCKET

The installation procedure is the reverse of the order of removal.

☞ Carefully check the mating parts of the travel reduction unit and the sprocket for burrs and contaminants.

1) Install the sprocket on the travel reduction unit.

2) Pass a wire rope around the travel reduction unit and lift it. Then install the travel reduction unit on the lower frame.

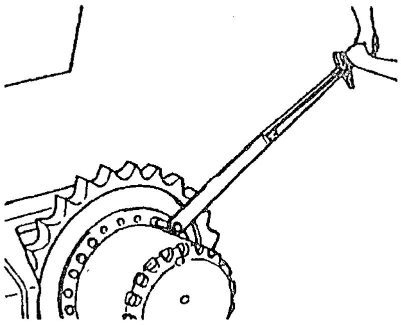


Fig. 80

3) Apply Three Bond 1306 (equivalent to Loctite # 262) to the 12 sprocket mounting cap screws (C), M14, and tighten them to the specified torque of 18.5±2 kgf·m (134±14 ft·lbs).

10. MAINTENANCE STANDARDS

10.1 TIGHTENING TORQUE FOR LOWER MOUNTING

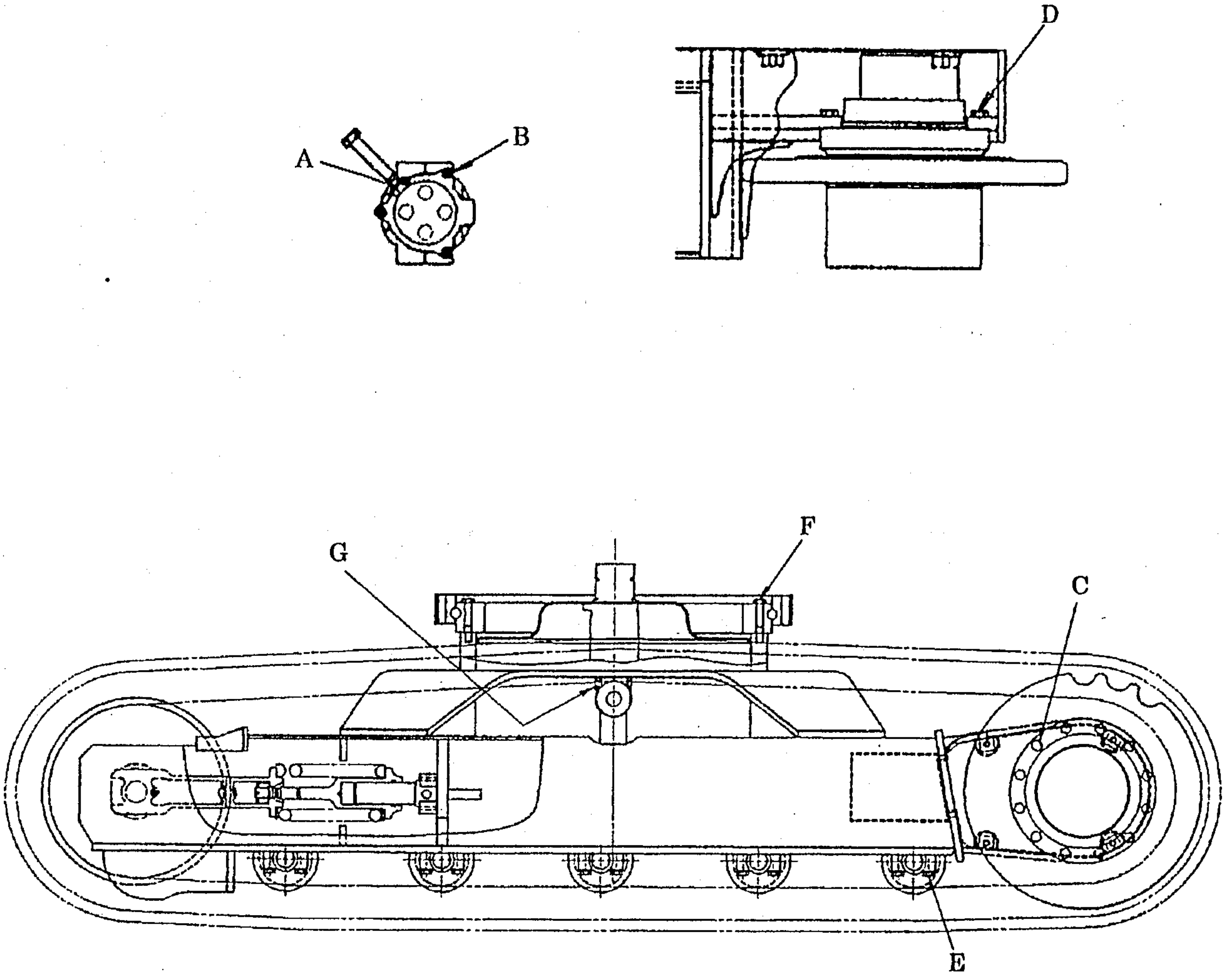


Fig. 81

Table 6 Unit : kgf · m (ft · lbs)

Symbol	Item	Standard Value	Remedy
A	For swivel joint fastening nut	16±1(116±7)	Retighten
B	Swivel joint mounting capscrews	3.6±0.3(26±2)	Apply Three Bond 1305 (Loctite #242) and retighten
C	For sprocket mounting capscrews	18.5±2(134±14)	
D	For reduction unit mounting capsrews	28.5±3(206±22)	
E	For lower roller mounting capscrews	18.5±2(134±14)	
F	For bearing mounting capscrews	28.5±3(206±22)	
G	For upper roller mounting capscrews	28.5±3(206±22)	

10.2 SPROCKET

mm (in)

Items	Pitch	78.7mm (3.1″)	Tooth number	21
	Roller dia	Ø41 (1.61″)		

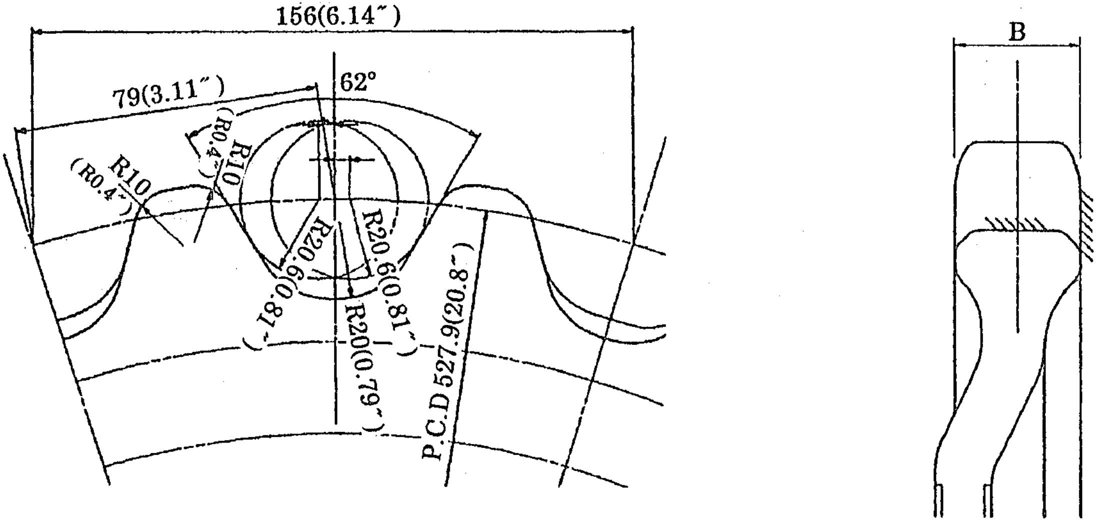

156(6.14″)
79(3.11″)
62°
R10
(R0.4″)
R10
(R0.4″)
R20.6(0.81″)
R20.6(0.81″)
R20(0.79″)
P.C.D 527.9(20.8″)
B

Fig. 82

Table 7 Unit: mm (ft · in)

Symbol	Item	Standard Value	Allowable Value	Remedy
A	Wear of sprocket tooth profile	———	4 (0.16″)	Correct by reinforcement
B	Width of sprocket teeth	$38^{+0.5}_{-2.5}$ $(1.50^{+0.02″}_{-0.10″})$	32 (1.26″)	Replace

10.3 TRACK SPRING

Set load: 4160±250kg (9170±550 lbs)

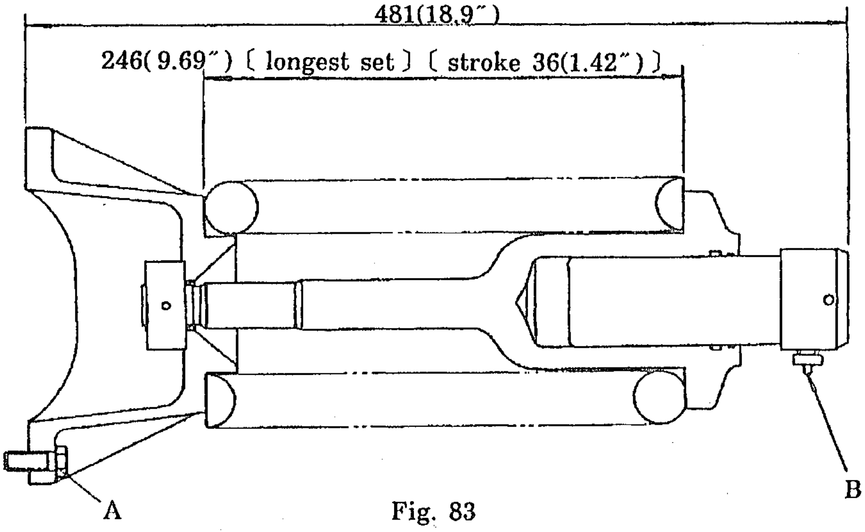

481(18.9″)
246(9.69″) [longest set] [stroke 36(1.42″)]
A
B

Fig. 83

Table 8 Unit: kgf · m (ft · lbs)

Symbol	Item	Standard Value	Remedy
A	Tightening torque of track spring mounting capscrews	11.7±1.2 (85±9)	Apply Three Bond 1305
B	Tightening torque of Grease nipple	6±1 (43±7)	———

10.4 TRACK LINK

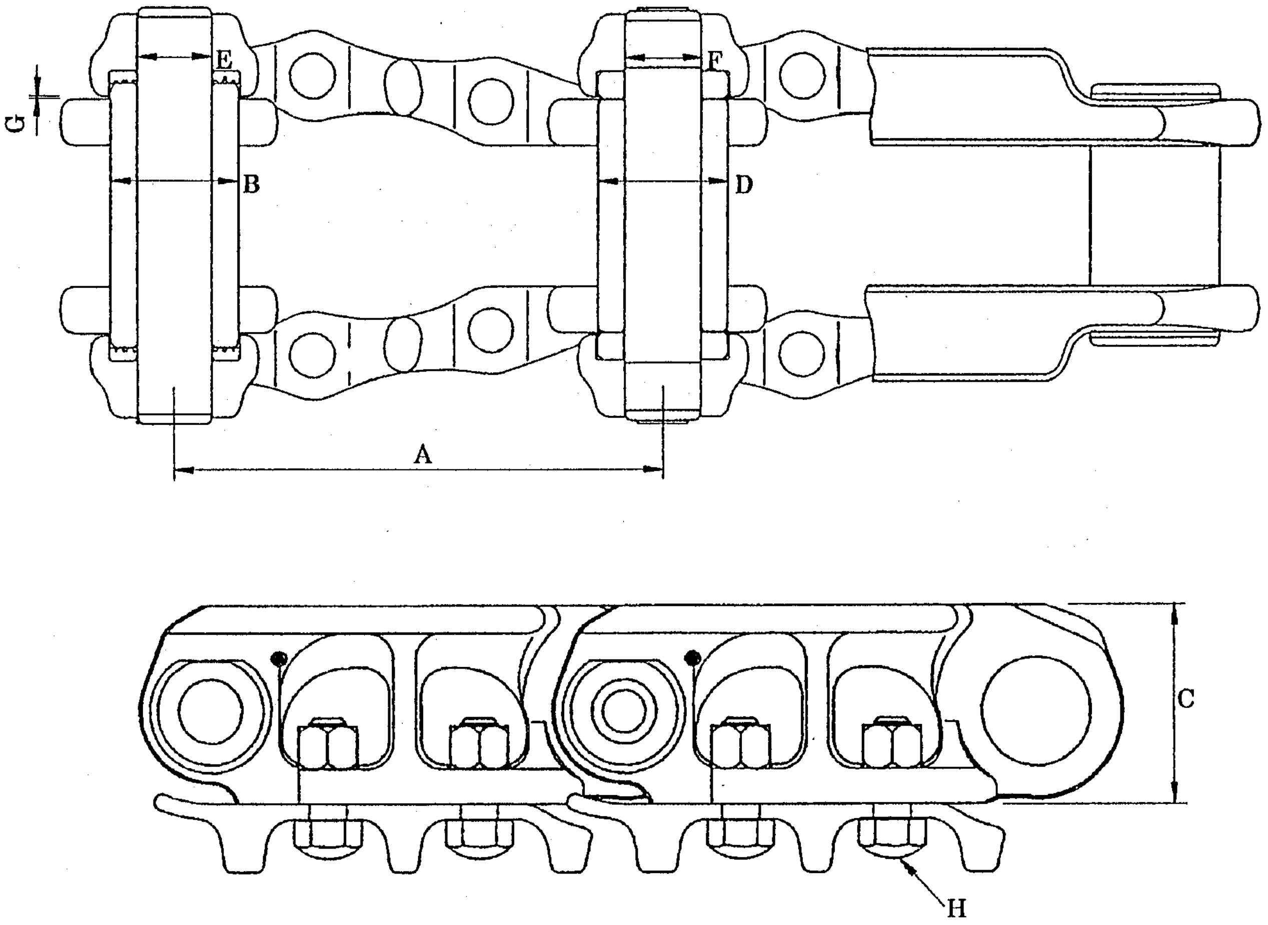


Fig.84

Table 9

Unit : mm(ft · in)

Sym-bol	Item	Standard Value				Allowable Value	Remedy
A	Ring pitch	155.6 (6.13″)				160(6.30″)	Replace.
B	Bush O.D.	$\varnothing 41^{+0.214}_{+0.174}$ ($\varnothing 1.6142''^{+0.0084''}_{+0.0069''}$)				Ø39(1.54″)	
C	Link height	75 (2.95″)				69(2.72″)	Replace.
		Basic dim	Tolerance		Standard interference	Allowable interference	
D	Shrinkage-fit interference of bush and link	Ø41 (1.6142″)	Shaft	+0.214 (0.0084″) +0.174 (0.0069″)	–	0.1 (0.004″)	Replace.
E	Shrinkage-fit interference of regular pin and link	Ø24 (0.9449″)	Shaft	±0.04 (0.0016″)	–	0.1 (0.004″)	
F	Shrinkage-fit interference of master pin and link	Ø24 (0.9449″)	Shaft	−0.05 (0.0020″) −0.08 (0.0031″)	–	0.05 (0.002″)	Replace with an oversize pin.
G	Link clearance	——				10(both sides)	Replace.
H	Tightening torque for shoe bolt	30±3kgf · m (217 ±22 ft · lbs)					Retighten

10.4.1 RUBBER CRAWLER (O.P.T)

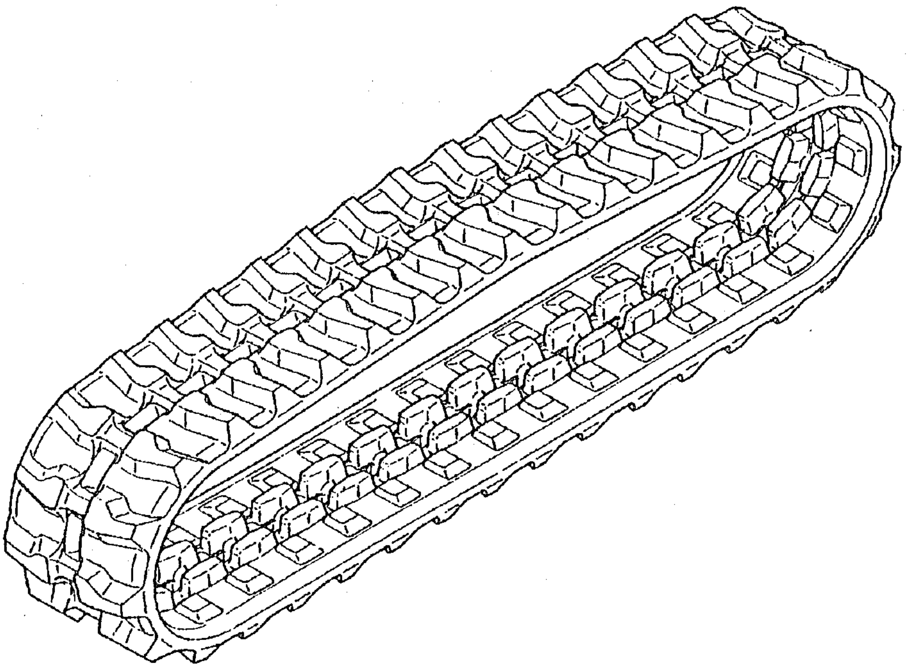
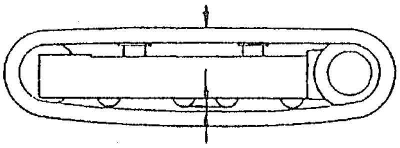
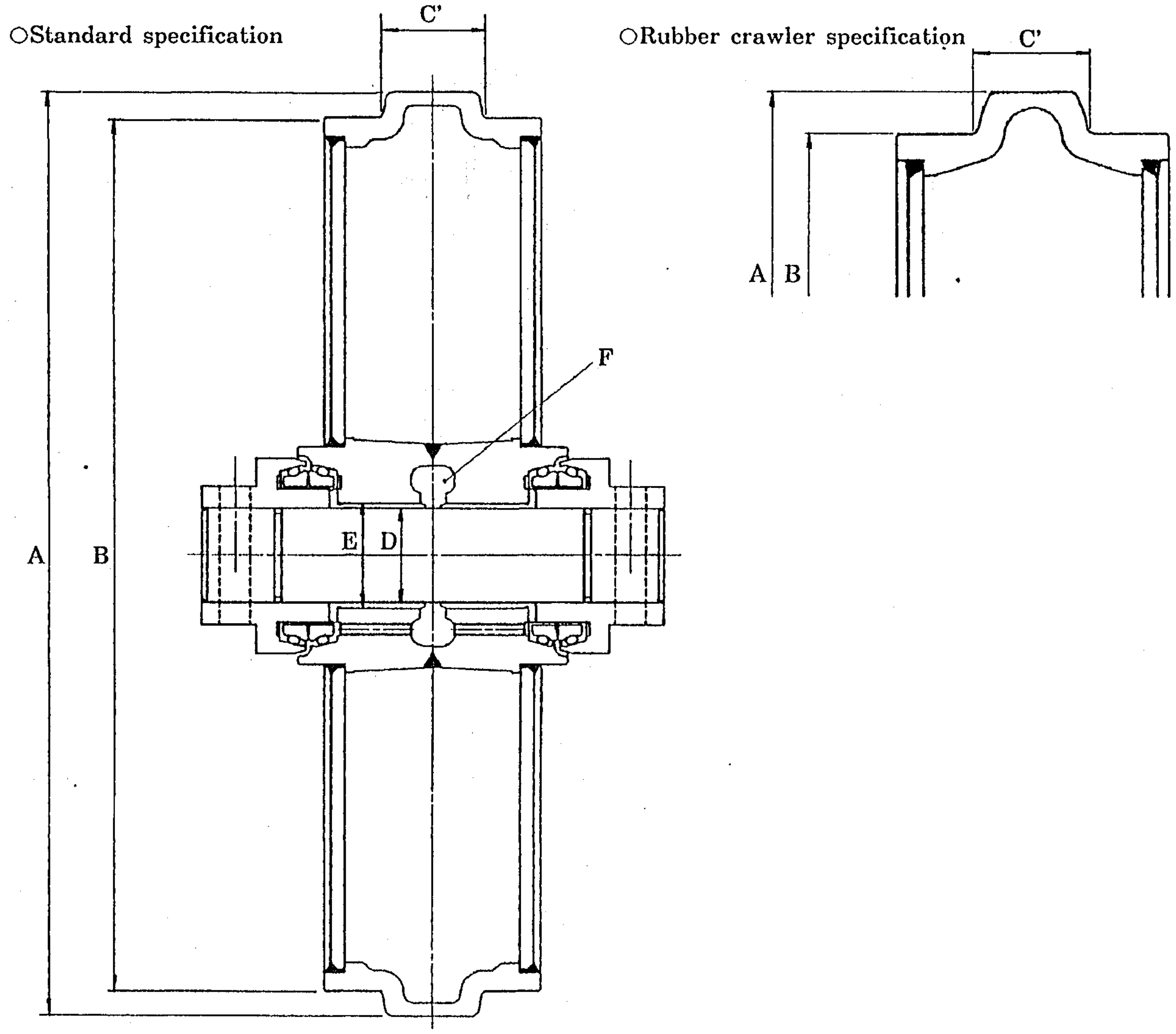


Fig. 85

	Check item	Acceptance criteria	Remedy
1	Rubber crawler tension (Check after 30 hours of use if the crawler is new.)	Place the joint in the center of the body.  10~15mm (0.39" ~0.59") (The 3rd roller from the sprocket)	In case it is more than 20mm(0.79"), tension must be readjusted.
2	Cracking and notch on rubber crawler	When the fault reaches the iron wire (steel cord).	Replace.
3	Disconnection or shearing-off of iron wire (steel cord)		Replace.
4	Area in contact with rubber crawler and lower roller	When more than half the core metal can be seen above the rubber crawler ;	Replace.

10.5 IDLER


○Standard specification

○Rubber crawler specification

Fig. 86

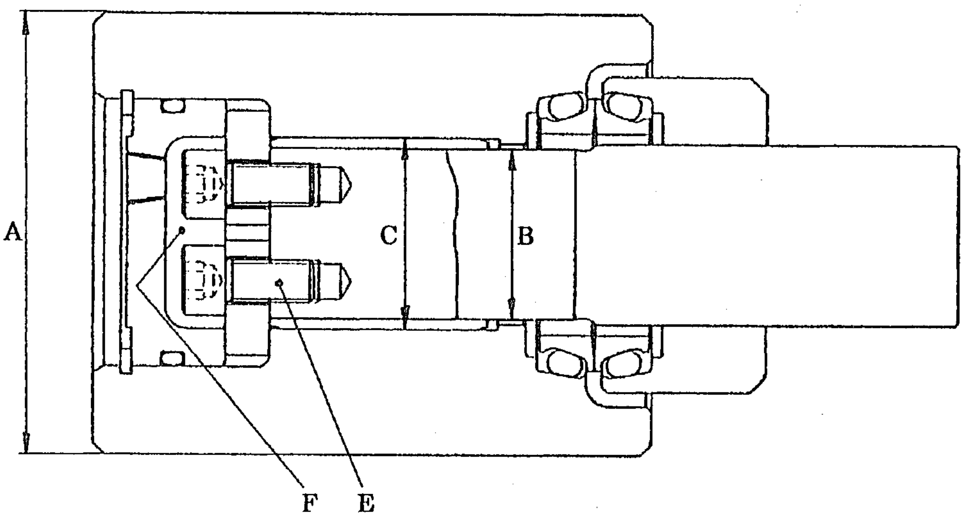
Table 10

Unit : mm (ft · in)

<table>
<tr><th rowspan="2">Sym-bol</th><th rowspan="2">Item</th><th colspan="4">Standard Value</th><th colspan="2">Allowable Value</th><th rowspan="2">Remedy</th></tr>
<tr><th colspan="3">Standard specification</th><th>Rubber crawler specification</th><th>Standard</th><th>Rubber</th></tr>
<tr><td>A</td><td>Diameter of idler protruding portion</td><td colspan="3">Ø432 (17.0″)</td><td>Ø453 (17.8″)</td><td>Ø426 (16.8″)</td><td>447 (17.6″)</td><td rowspan="3">Replace.</td></tr>
<tr><td>B</td><td>Diameter of track shoe contract surface</td><td colspan="3">Ø400 (15.7″)</td><td>Ø400 (15.7″)</td><td>Ø394 (15.5″)</td><td>394 (15.5″)</td></tr>
<tr><td>C</td><td>Flange width</td><td colspan="3">42 (1.65″)</td><td>42 (1.65″)</td><td>C'=36 (1.42″)</td><td>C'=37 (1.46″)</td></tr>
<tr><td rowspan="2">D</td><td rowspan="2">Clearance between shaft and bushing</td><td>Basic dim</td><td colspan="2">Allowable interference</td><td>Standard</td><td colspan="2">Allowable</td><td rowspan="3">Replace bushing</td></tr>
<tr><td>Ø50
(1.9685″)</td><td>Shaft</td><td>−0.050
(−0.0020″)
−0.075
(−0.0030″)</td><td>Clearance
−</td><td colspan="2">Clearance
2.0 (0.08″)</td></tr>
<tr><td>E</td><td>Interference of roller and bushing</td><td>Ø57
(2.2441″)</td><td>Bore</td><td>+0.030
(0.0012″)
−0.020
(−0.0008″)</td><td>Interference
−</td><td colspan="2">Interference
0</td></tr>
<tr><td>F</td><td>Oil</td><td colspan="6">Engine oil API, Class CD #30 160cc (9.76 cuin)</td><td>Refill</td></tr>
</table>

10.6 UPPER ROLLER

○Standard specification



○Rubber crawler specification

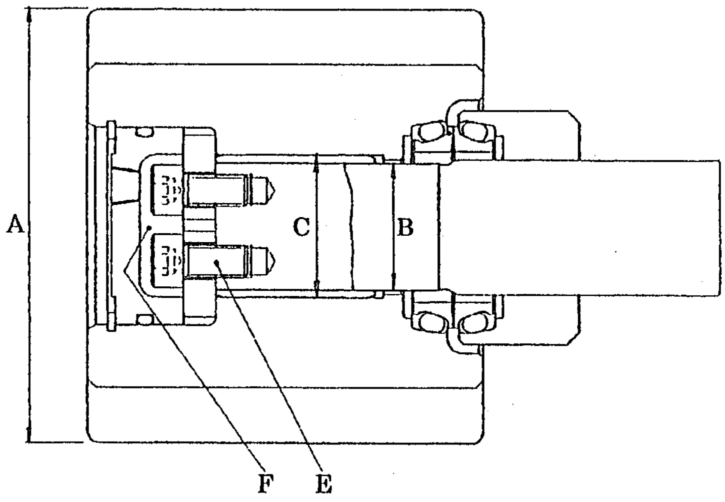


Fig. 87

Table 11

Unit : mm(ft · in)

<table>
<tr><th rowspan="2">Sym-
bol</th><th rowspan="2">Item</th><th colspan="4">Standard Value</th><th colspan="2">Allowable Value</th><th rowspan="2">Remedy</th></tr>
<tr><th colspan="2">Standard specification</th><th colspan="2">Rubber crawler specification</th><th>Standard</th><th>Rubber</th></tr>
<tr><td>A</td><td>Diameter of track shoe contract surface</td><td colspan="2">Ø82 (3.23″)</td><td colspan="2">Ø110 (4.33″)</td><td>Ø72
(2.83″)</td><td>Ø87
(3.43″)</td><td>Replace</td></tr>
<tr><td rowspan="2">B</td><td rowspan="2">Clearance between shaft and bushing</td><td>Basic dim</td><td colspan="2">Allowable tolerance</td><td>Standard</td><td colspan="2">Allowable</td><td rowspan="3">Replace bushing</td></tr>
<tr><td>Ø32
(1.2598″)</td><td>Shaft</td><td>−0.025
(−0.0010″)
−0.050
(−0.0020″)</td><td>Clearance
—</td><td colspan="2">Clearance
0.05
(0.002″)</td></tr>
<tr><td>C</td><td>Interference of roller and bushing</td><td>Ø36
(1.4173″)</td><td>Bore</td><td>0
+0.030
(0.0012″)</td><td>Interference
—</td><td colspan="2">Interference
0</td></tr>
<tr><td>E</td><td>Tightening torque of socket screw</td><td colspan="6">3.4±0.35kgf · m (25±3 ft · lbs)</td><td>Loctite #242 or Three Bond 1360K</td></tr>
<tr><td>F</td><td>Oil</td><td colspan="6">Engine oil API, Class CD #30 20 cc (1.22 cuin)</td><td>Refill</td></tr>
</table>

10.7 LOWER ROLLER

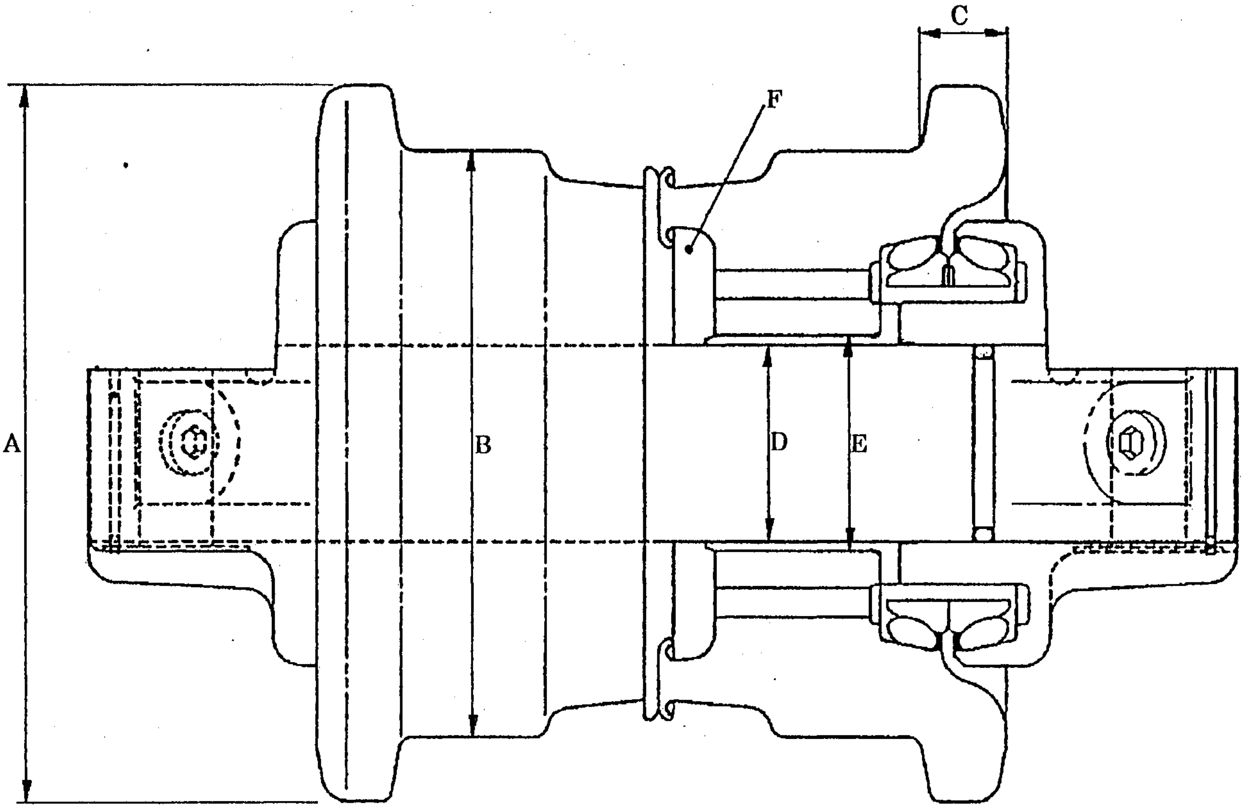


Fig. 88

Table 12

Unit: mm(ft · in)

Sym-bol	Item	Standard Value				Allowable Value	Remedy
A	Flange O. D	⌀147 (5.79″)				⌀135 (5.31″)	Replace
B	Diameter of track shoe contract surface	⌀120 (4.72″)				⌀108 (4.25″)	
C	Flange width	17.5 (0.69″)				12 (0.47″)	
D	Clearance between shaft and bushing	Basic dim	Allowable tolerance		Standard	Allowable	Replace bushing
		⌀40 (1.5748″)	Shaft	−0.050 (−0.0020″) −0.075 (−0.0030″)	Clearance —	Clearance 0.8 (0.031″)	
E	Interference of roller and bushing	⌀44 (1.7323″)	Bore	+0.025 (0.0010″) −0.020 (−0.0008″)	Interference —	Interference 0	Replace
F	Oil	Engine oil API, Class CD #30 90cc (5.49 cuin)					Refill

BooK code No. S5LE2107E

KOBELCO

SHOP MANUAL SK60

ATTACHMENTS

LE 21

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	3	A			A	A	B	A	A	A	A	A	A	A	A	A	A	A		
	4	A			A	A	B	A	A	A	A	A	A	A	A	A	A	A		
	6	B			B	B	B	A	A	A	A	A	A	A	A	A	A	A		
	12	A			B	B	B	A	A	A	A	A	A	A	A	A	A	A		

Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE2107E K

1. OPERATION OF WORKING ATTACHMENT SYSTEM

1.1 GENERAL

The working arrachment is moved hydraulically, and is controlled by pilot pressure. The various operating circuits and how they operate are described below.

[Operation of boom]

When the boom is raised, the oil from two pumps is merged to speed up the action. Boom lowering operation is executed by a single pump.

[Operation of arm]

When the arm is retracted under a light load, a variable return oil recirculation circuit speeds up the action. When the arm is retracted under a heavy load, the variable recirculation circuit is closed off, and a circuit for automatically merging the oil from two pumps is completed to speed up the action. When the arm is retracted while the upper frame is being swung, a swing priority circuit is completed. When the arm is extended, the oil from two pumps is merged.

[Operation of bucket]

Whether the bucket is being retracted or extended, only one pupm is used. During simultaneous travel and working attachment operation, one pump is assigned to travel and the other is assigned to working attachment operation.

1.2 CONNECTING THE ATTACHMENT DRIVE PIPING

(1) Hydraulic tank and control valve
(See Table 1, Fig,.)

Table 1 (Connecting port signs)

Component / Circuits	Hydraulic tank	Pump ①	Control valve③
Feed	Tank	A1 A2	P1 P2
Return	Tank Oil cooler		T1 T2

(2) Piping between control valve and cylinders

Table 2 (Connecting port signs)

Operation / Component			Pump	Control valve	Cylinder
Boom raising		Feed	A1 A2	P1 P2 — B2	H
		Return	–	T–A2	R
Boom lowering		Feed	A1	P1–A2	R
		Return	–	T–B2	H
Arm digging	Light load	Feed	A2	P2–B5	H
		Return	–	T–A5	R
	Heavy load	Feed	A1 A2	P1 P2 — B5	H
		Return	–	T–A5	R
Arm extention		Feed	A1 A2	P1 P2 — A5	R
		Return	–	T–B5	H
Bucket digging		Feed	A1	P1–B1	H
		Return	–	T–A1	R
Bucket dischange		Feed	A1	P1–A1	R
		Return	–	T–B1	H

1. OPERATION OF WORKING ATTACHMENT SYSTEM

1.1 GENERAL

The working arrachment is moved hydraulically, and is controlled by pilot pressure. The various operating circuits and how they operate are described below.

[Operation of boom]

When the boom is raised, the oil from two pumps is merged to speed up the action. Boom lowering operation is executed by a single pump.

Holding valves (safety) are equipped on the return line of the boom lowering side to prevent fall of the boom by means of the safety valve when the hydraulic circuit should rupture.

[Operation of arm]

When the arm is retracted under a light load, a variable return oil recirculation circuit speeds up the action. When the arm is retracted under a heavy load, the variable recirculation circuit is closed off, and a circuit for automatically merging the oil from two pumps is completed to speed up the action. When the arm is retracted while the upper frame is being swung, a swing priority circuit is completed. When the arm is extended, the oil from two pumps is merged.

[Operation of bucket]

Whether the bucket is being retracted or extended, only one pupm is used. During simultaneous travel and working attachment operation, one pump is assigned to travel and the other is assigned to working attachment operation.

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(1) Hydraulic tank and control valve
(See Table 1, Fig,.)

Table 1 (Connecting port signs)

Component Circuits	Hydraulic tank	Pump ①	Control valve③
Feed	Tank ▷	A1 A2	▷ P1 ▷ P2
Return	Tank ◁	Oil cooler	◁T1 ◁T2

(2) Piping between control valve and cylinders

Table 2 (Connecting port signs)

Operation \ Component			Pump	Control valve	Boom safety	Cylinder
Boom raising		Feed	A1 A2	P1 P2 — B2	B2 — A	▷H
		Return	–	T – A2		◁R
Boom lowering		Feed	A1	P1 – A2		▷R
		Return	–	T – B2	B2 — A	◁H
Arm digging	Light load	Feed	A2	P2 – B5		▷ H
		Return	–	T – A5		◁R
	Heavy load	Feed	A1 A2	P1 P2 — B5		▷ H
		Return	–	T – A5		◁ R
Arm extention		Feed	A1 A2	P1 P2 — A5		▷ R
		Return	–	T – B5		◁ H
Bucket digging		Feed	A1	P1 – B1		▷ H
		Return	–	T – A1		◁ R
Bucket dischange		Feed	A1	P1 – A1		▷ R
		Return	–	T – B1		◁H

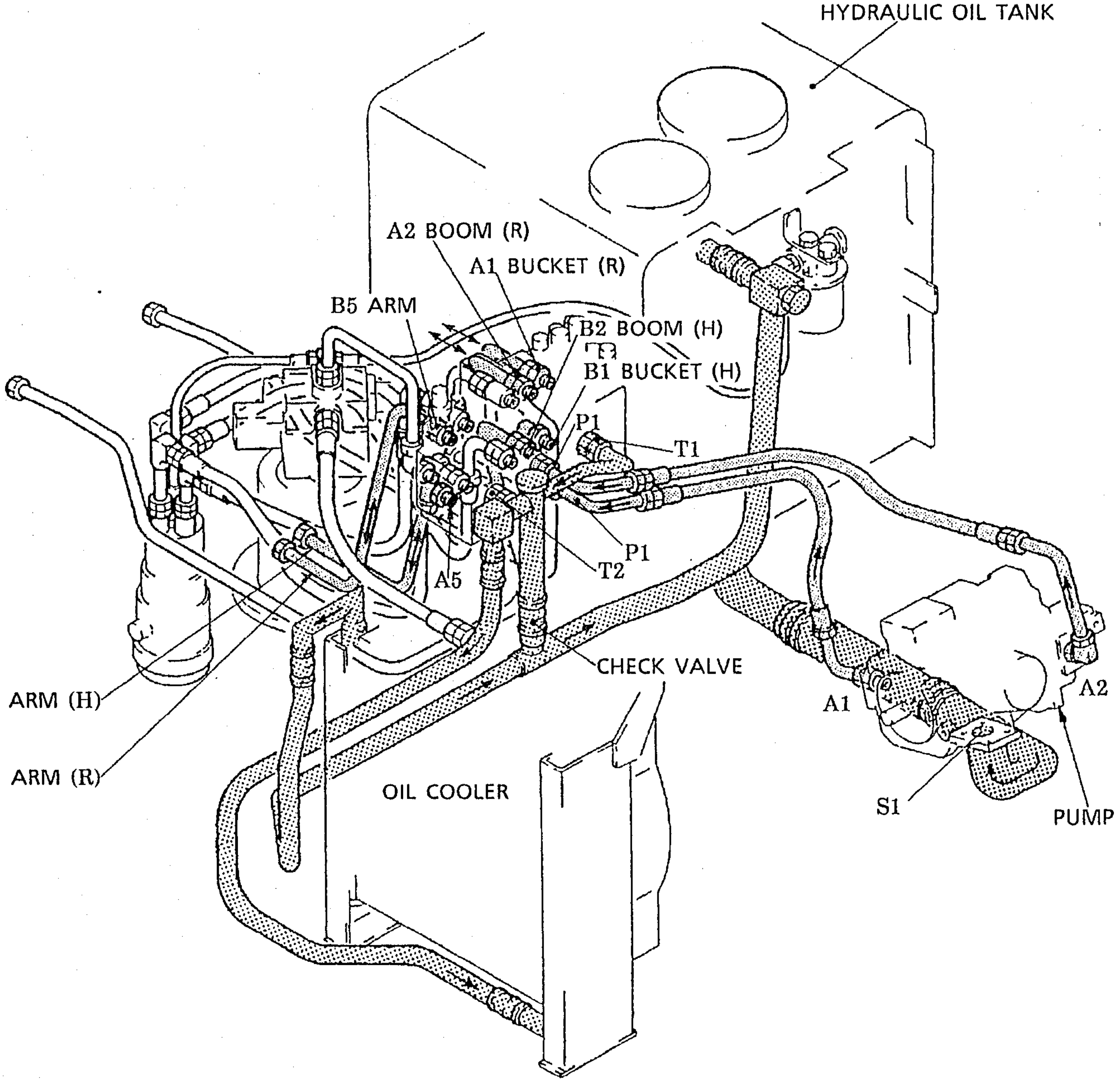

HYDRAULIC OIL TANK
A2 BOOM (R)
A1 BUCKET (R)
B5 ARM
B2 BOOM (H)
B1 BUCKET (H)
P1
T1
P1
T2
A5
CHECK VALVE
A1
A2
ARM (H)
ARM (R)
OIL COOLER
S1
PUMP

Fig. 1 Oil flow for attachment cylinder drive

1.3 ATTACHMENT PILOT SYSTEM

Introduce the delivery pressure of the gear pump or the primary pilot pressure to the control valve and the pilot valve as the pressure source for the pilot system.

The hydraulic pressure discharged by operation, changeover and manipulation of these devices or the secondary pilot pressure actuates the following devices so as to operate the attachment.

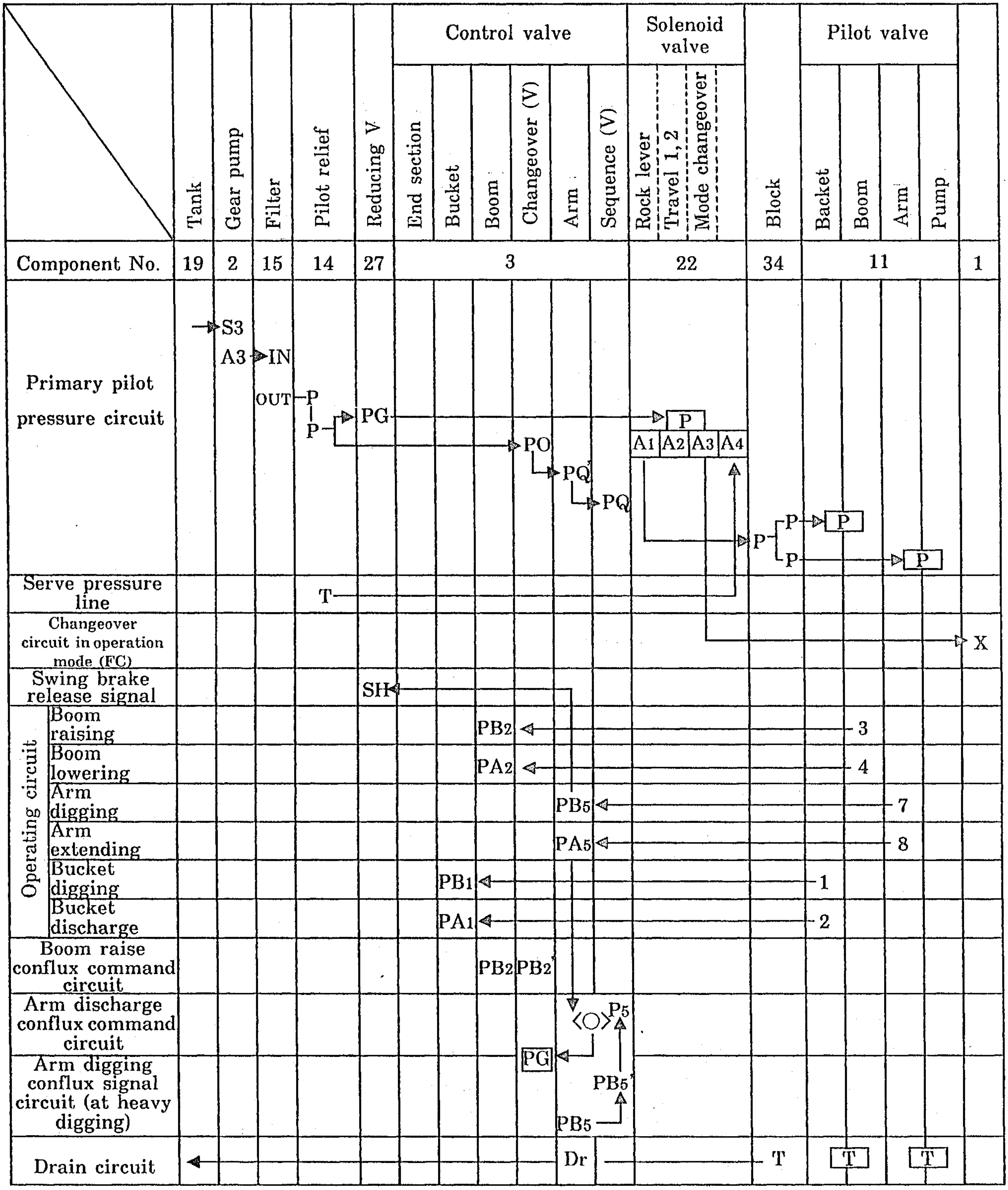
1.3.1 CONNECTING THE ATTACHMENT PILOT PIPING

1) The hydraulic piping for the attachment pilot pressure are as shown in Table 3 and Fig.2.

2) The attachment pilot piping are classified systematically as follows:

   a. Primary pilot (delivery) circuit
   b. Boost pressure circuit
   c. Operation mode (FC) changeover
   d. Swing brake release signal circuit
   e. Operating circuit (secondary pilot pressure)
   f. Conflux signal circuit
   g. Drain circuit

Table 3A (Connecting port signs)

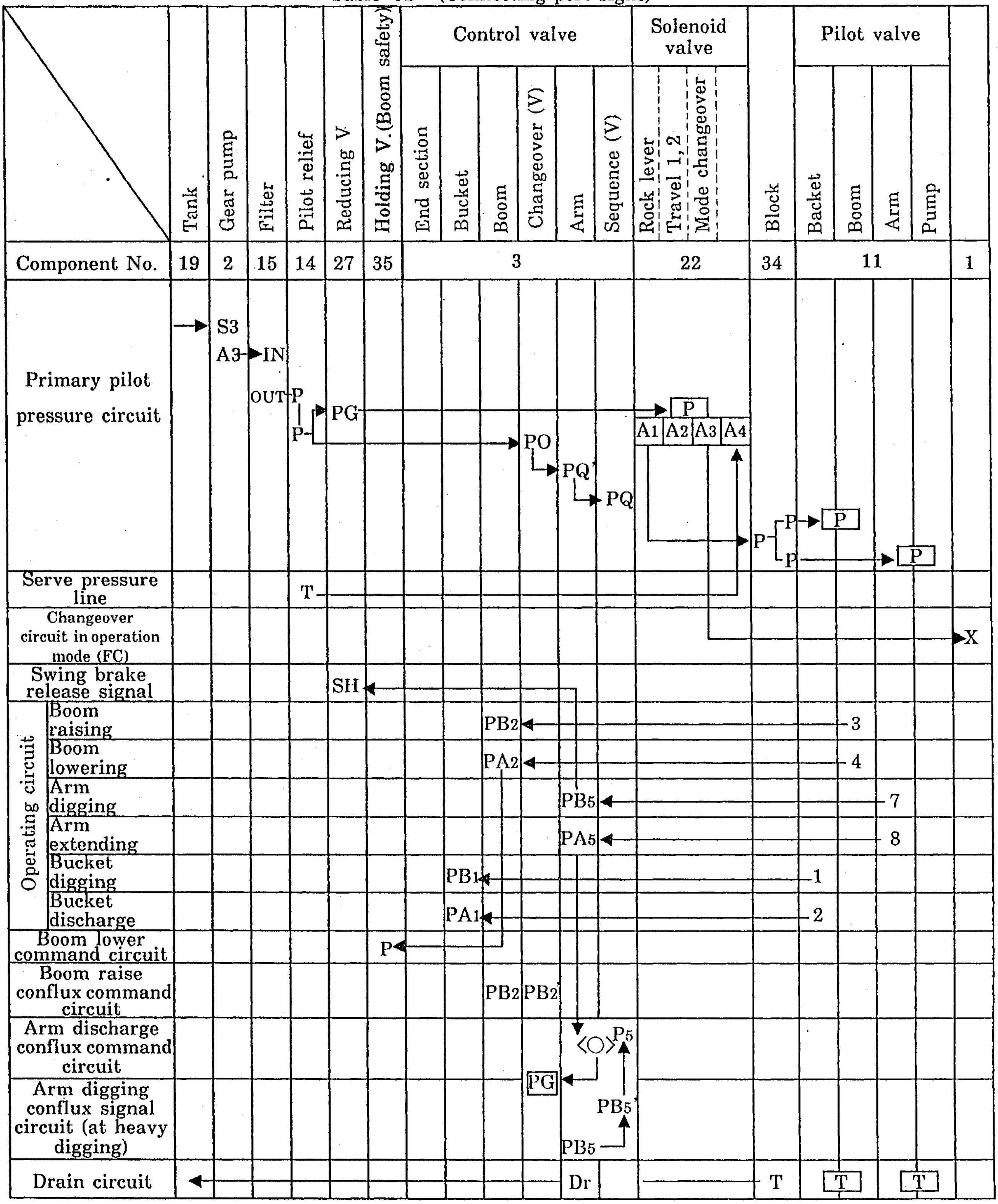


						Control valve						Solenoid valve				Pilot valve				
	Tank	Gear pump	Filter	Pilot relief	Reducing V	End section	Bucket	Boom	Changeover (V)	Arm	Sequence (V)	Rock lever	Travel 1,2	Mode changeover	Block	Backet	Boom	Arm	Pump	
Component No.	19	2	15	14	27	3						22			34	11				1
Primary pilot pressure circuit		S3 A3	IN OUT	P P	PG				PO	PQ	PQ	P A1	A2	A3 A4	P P P	P			P	
Serve pressure line				T																
Changeover circuit in operation mode (FC)																				X
Swing brake release signal					SH															
Operating circuit: Boom raising								PB2									3			
Operating circuit: Boom lowering								PA2									4			
Operating circuit: Arm digging										PB5								7		
Operating circuit: Arm extending										PA5								8		
Operating circuit: Bucket digging							PB1									1				
Operating circuit: Bucket discharge							PA1									2				
Boom raise conflux command circuit								PB2	PB2'											
Arm discharge conflux command circuit									PG	⟨O⟩	P5									
Arm digging conflux signal circuit (at heavy digging)										PB5	PB5'									
Drain circuit	◀									Dr					T	T			T	

1.3.1 CONNECTING THE ATTACHMENT PILOT PIPING

1) The hydraulic piping for the attachment pilot pressure are as shown in Table 3 and Fig.2.
2) The attachment pilot piping are classified systematically as follows:
   a. Primary pilot (delivery) circuit
   b. Boost pressure circuit
   c. Operation mode (FC) changeover
   d. Swing brake release signal circuit
   e. Operating circuit (secondary pilot pressure)
   f. Holding valve, boom lower command circuit
   g. Conflux signal circuit
   h. Drain circuit

Table 3B (Connecting port signs)



	Tank	Gear pump	Filter	Pilot relief	Reducing V	Holding V.(Boom safety)	Control valve End section	 Bucket	 Boom	 Changeover (V)	 Arm	 Sequence (V)	Solenoid valve Rock lever / Travel 1,2 / Mode changeover	Block	Pilot valve Backet	 Boom	 Arm	 Pump	
Component No.	19	2	15	14	27	35	3						22	34	11				1
Primary pilot pressure circuit	→	S3 A3→	IN OUT	P P	PG					PO	PQ'	PQ	P A1 A2 A3 A4	P P P		P		P	
Serve pressure line				T															
Changeover circuit in operation mode (FC)																			X
Swing brake release signal					SH														
Operating circuit: Boom raising									PB2							3			
Operating circuit: Boom lowering									PA2							4			
Operating circuit: Arm digging											PB5						7		
Operating circuit: Arm extending											PA5						8		
Operating circuit: Bucket digging								PB1							1				
Operating circuit: Bucket discharge								PA1							2				
Boom lower command circuit						P													
Boom raise conflux command circuit									PB2	PB2'									
Arm discharge conflux command circuit											〈O〉	P5							
Arm digging conflux signal circuit (at heavy digging)										PG	PB5	PB5'							
Drain circuit	←										Dr			T		T		T	

1.3.2 FUNCTIONAL EXPLANATION OF ATTACHMENT PILOT PRESSURE PIPING

1) Primary pilot pressure (delivery) circuit

The hydraulic pressure discharged from gear pump (2) i.e. the primary pilot pressure flows tables 3A.

2) Servo pressure circuit

If the oil relieved from port T of relief valve (14) tries to the tank port, the pressure of the oil is held as check valve (21) (set at 7kgf/cm^2) is provided at the inlet of the tank port. The circuit is connected with the supply circuit of the swing motor and port A4 of solenoid valve (22). The pressure which enters the solenoid valve becomes the pump control pressure for the FC operation mode changeover.

3) Operation mode (FC) changeover circuit

If the operation mode switch is turned to FC, the servo pressure from port A3 of solenoid valve (22) is admitted to port X of the pump as the mode changeover signal pressure, enters the regulator of the pump and decreases the delivery rate of the pump.

4) Swing brake release signal circuit

When the arm is retracted, pilot pressure flows from Port PB5 of the control valve to Port SH of the pressure reducing valve (27), shifting the reducing valve and releasing the swing brake.

5) Operating circuit (secondary pilot pressure)

If the operating lever of the attachment is moved, the primary pressure in port P of pilot valve (11) is connected with each of the discharge ports. This causes the oil to flow to the operating circuit and connect with each with each of the pilot ports of the control valve.

The secondary pressure which enters the control valve shifts the control valve spool so as to let the drive oil to each of the cylinders.

6) Conflux signal circuit

a) At boom hoisting

The secondary pressure which enters port PB2 of the control valve changes over the boom conflux valve in the control valve. This causes the discharged oil of the P2 pump to be combined with the secondary pressure. When both travel and boom hoisting motions are executed at the same time, the oil pressure in the control valve port PO changes over the straightpressure in the control valve port PO changes over the straight travel valve in the valve to direct the discharged oil of the No.1 pump to both motors. Accordingly, boom hoisting is operated by the No.2 pump alone.

b) At heavy digging with arm

In heavy arm digging operation, the pressure in the main circuit rises by which the sequence valve is switched over automatically.

When the sequence valve is changed over, the arm digging control pressure (secondary pilot pressure) connects with port P5 through port PB5 of the sequence valve.

The pressure connected with port PG through port P5 changes over the neutral cut valve in the valve and the arm conflux valve.

As the result, the discharged oil of the P1 pump is combined with the pressure.

c) At arm discharge

The moment the arm discharge control pressure enters port PA5, it connects with port PG, switches over the arm conflux changeover valve and combines the pressure with the oil discharged from the pump.

7) Drain circuit

The oil leaking from the components are combined together and returned directly to the hydraulic oil tank.

1.3.2 FUNCTIONAL EXPLANATION OF ATTACHMENT PILOT PRESSURE PIPING

1) Primary pilot pressure (delivery) circuit
The hydraulic pressure discharged from gear pump (2) i.e. the primary pilot pressure flows tables 3B.

2) Servo pressure circuit
If the oil relieved from port T of relief valve (14) tries to the tank port, the pressure of the oil is held as check valve (21) (set at 7kgf/cm^2) is provided at the inlet of the tank port. The circuit is connected with the supply circuit of the swing motor and port A4 of solenoid valve (22). The pressure which enters the solenoid valve becomes the pump control pressure for the FC operation mode changeover.

3) Operation mode (FC) changeover circuit
If the operation mode switch is turned to FC, the servo pressure from port A3 of solenoid valve (22) is admitted to port X of the pump as the mode changeover signal pressure, enters the regulator of the pump and decreases the delivery rate of the pump.

4) Swing brake release signal circuit
When the arm is retracted, pilot pressure flows from Port PB5 of the control valve to Port SH of the pressure reducing valve (27), shifting the reducing valve and releasing the swing brake.

5) Operating circuit (secondary pilot pressure)
If the operating lever of the attachment is moved, the primary pressure in port P of pilot valve (11) is connected with each of the discharge ports. This causes the oil to flow to the operating circuit and connect with each with each of the pilot ports of the control valve.
The secondary pressure which enters the control valve shifts the control valve spool so as to let the drive oil to each of the cylinders.

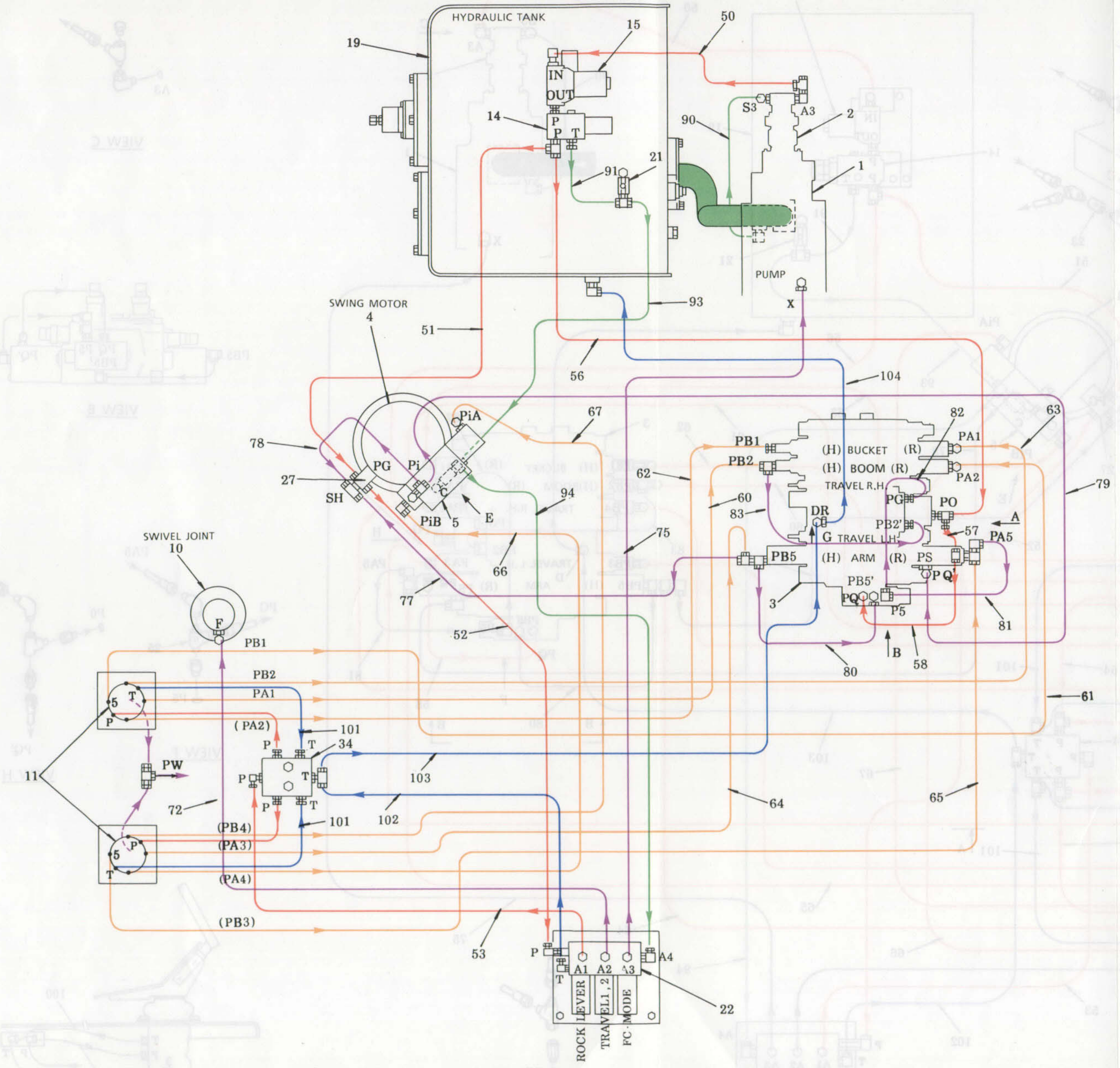
6) Holding valve, boom lower command circuit
When pressurized oil enters Port P of the holding valve (34) from Port PA2 of the control valve, holding valves are changed over and allow the returned oil from the boom cylinder (H) to bring back to the hydraulic oil tank by way of port B2 of the control valve.

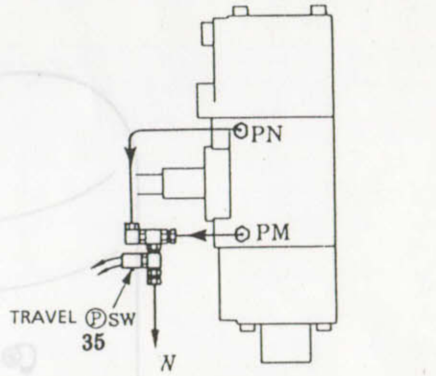
7) Conflux signal circuit
   a) At boom raise
   The secondary pressure which enters port PB2 of the control valve changes over the boom conflux valve in the control valve. This causes the discharged oil of the P2 pump to be combined with the secondary pressure. When both travel and boom hoisting motions are executed at the same time, the oil pressure in the control valve port PO changes over the straightpressure in the control valve port PO changes over the straight travel valve in the valve to direct the discharged oil of the No.1 pump to both motors. Accordingly, boom hoisting is operated by the No.2 pump alone.
   b) At heavy digging with arm
   In heavy arm digging operation, the pressure in the main circuit rises by which the sequence valve is switched over automatically.
   When the sequence valve is changed over, the arm digging control pressure (secondary pilot pressure) connects with port P5 through port PB5 of the sequence valve.
   The pressure connected with port PG through port P5 changes over the neutral cut valve in the valve and the arm conflux valve.
   As the result, the discharged oil of the P1 pump is combined with the pressure.
   c) At arm discharge
   The moment the arm discharge control pressure enters port PA5, it connects with port PG, switches over the arm conflux changeover valve and combines the pressure with the oil discharged from the pump.

8) Drain circuit
The oil leaking from the components are combined together and returned directly to the hydraulic oil tank.

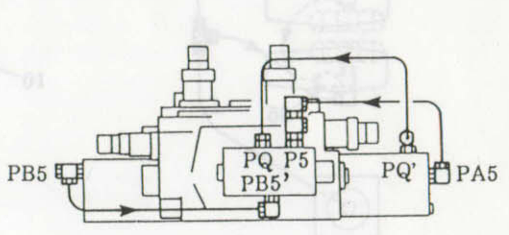
No.	Component Name	No.	Component Name	No.	Component Name
1	Main pump	14	Pilot relief valve	27	Reducing valve
2	Gear pump	15	Line filter	31	Travelling pilot valve R.H
3	Main control valve	19	Hydraulic tank	32	Travelling pilot valve L.H
4	Swing motor ass'y	21	Check valve	34	Block
5	Swing control valve	22	Solenoid valve	35	Pressure switch
10	Swivel joint	23	Check valve		
11	Operating pilot valve	25	Tee & Ball		

Piping			Component No. & Conecting port		Remarks
No.	Classification		From	To	
50	Pink color	Primary pilot pressure circuit	2-OUT	15-IN	Primary pilot pressure delivery
51			14-P	27-PG	For Automatic swing parking release
52			27-PG	22-P	For Solenoid valve (22)
53			22-A1	34-P	For Block (34)
54			34-P	11-P	For Operating pilot valve (11)
55			34-P	31,32-P	For Travelling pilot valve (31, 32)
56			14-P	3-P0	Servo pressure for control valve side by-pass
57			3-P0	3-PQ'	Arm confluence valve changeover for Arm spool
58			3-PQ'	3-PQ	Arm confluence valve changeover for Sequence
60	Orange color	Operating circuit (Secondary pilot pressure circuit)	11-3	3-PB2	Boom raise (PA1)
61			11-4	3-PA2	Boom lower (PB1)
62			11-1	3-PB1	Bucket digging (PA2)
63			11-2	3-PA1	Bucket discharge (PB2)
64			11-7	3-PB5	Arm digging (PA3)
65			11-8	3-PA5	Arm extending (PB3)
66			11-5	5-PiB	Swing L. H. (PA4)
67			11-6	5-PiA	Swing R. H. (PB4)
72	Violet color	Command or Signal circuit	22-A2	10-F	Travelling motor 2-speed changeover
75			22-A3	1-X	FC mode changeover
77			3-PB5	27-SH	Reducing valve changeover in Arm digging
78			5-Pi	27-SH	Reducing valve changeover in Swing
79			5-Pi	3-PS	Swing priority in Swing and Arm digging
80			3-PB5	3-PB5'	Arm confluent in Arm heavy digging
81			3-PA5	3-P5	Arm confluent in Arm extending
82			3-P5	3-PG	Arm confluent in Arm heavy digging or Arm extending
83			3-PB2	3-PB2'	Boom raise conflux
84			3-PA2	34-P	Holding valve, boom lower command circuit
86	Orange color	Steering circuit	32-1	3-PA3	Travel steering circuit L.H. advance
87			32-2	3-PB3	Travel steering circuit L.H. retreat
88			31-2	3-PA4	Travel steering circuit R.H. advance
89			31-1	3-PB4	Travel steering circuit L.H. retreat
90	Grean color	Servo circuit	19	2-S3	Gear pump
91			14-T	21	Relief valve for Tank circuit
93			21	5-C	Swing boost pressure
94			5-C	22-A4	Boost pressure in FC mode
100	Blue color	Drain circuit	31,32-T	34-T	From Travelling valve (31, 32)
101			11-T	34-T	From Operating valve (11)
102			22-T	34-T	From Solenoid valve (22)
103			34-T	3-DR	From Block
104			3-Dr	19	From Main control valve (3)

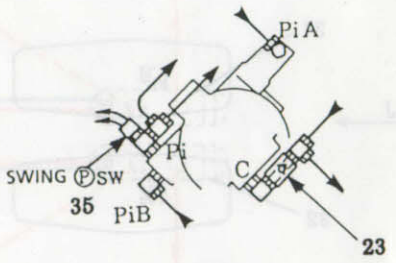

HYDRAULIC TANK
19
15
50
IN
OUT
14
P
P T
S3
A3
2
90
1
21
91
PUMP
X
93
SWING MOTOR
4
51
56
104
82
63
PB1
(H) BUCKET (R)
PA1
PB2
(H) BOOM (R)
PA2
TRAVEL R.H
78
PiA
67
PG
Pi
27
SH
C
E
PiB
5
62
60
83
94
75
PG
PO
A
PB2'
57
PA5
DR
G TRAVEL L.H
PB5
(H) ARM (R)
PS
PQ'
79
SWIVEL JOINT
10
66
77
PB5'
PQ
P5
3
81
F
52
PB1
80
B
58
PB2
PA1
61
11
5
T
P
PW
(PA2)
101
34
P
T
103
72
101
102
64
65
(PB4)
(PA3)
(PA4)
(PB3)
53
P
T
A1
A2
A3
A4
22
ROCK LEVER
TRAVEL1, 2
FC-MODE


PN
PM
TRAVEL Ⓟ SW
35
N

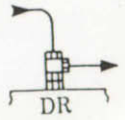
VIEW A


PB5
PQ
P5
PB5'
PQ'
PA5

VIEW B


PiA
Pi
SWING Ⓟ SW
35
PiB
C
23

VIEW E



VIEW G

Fig. 2A Pirot piping

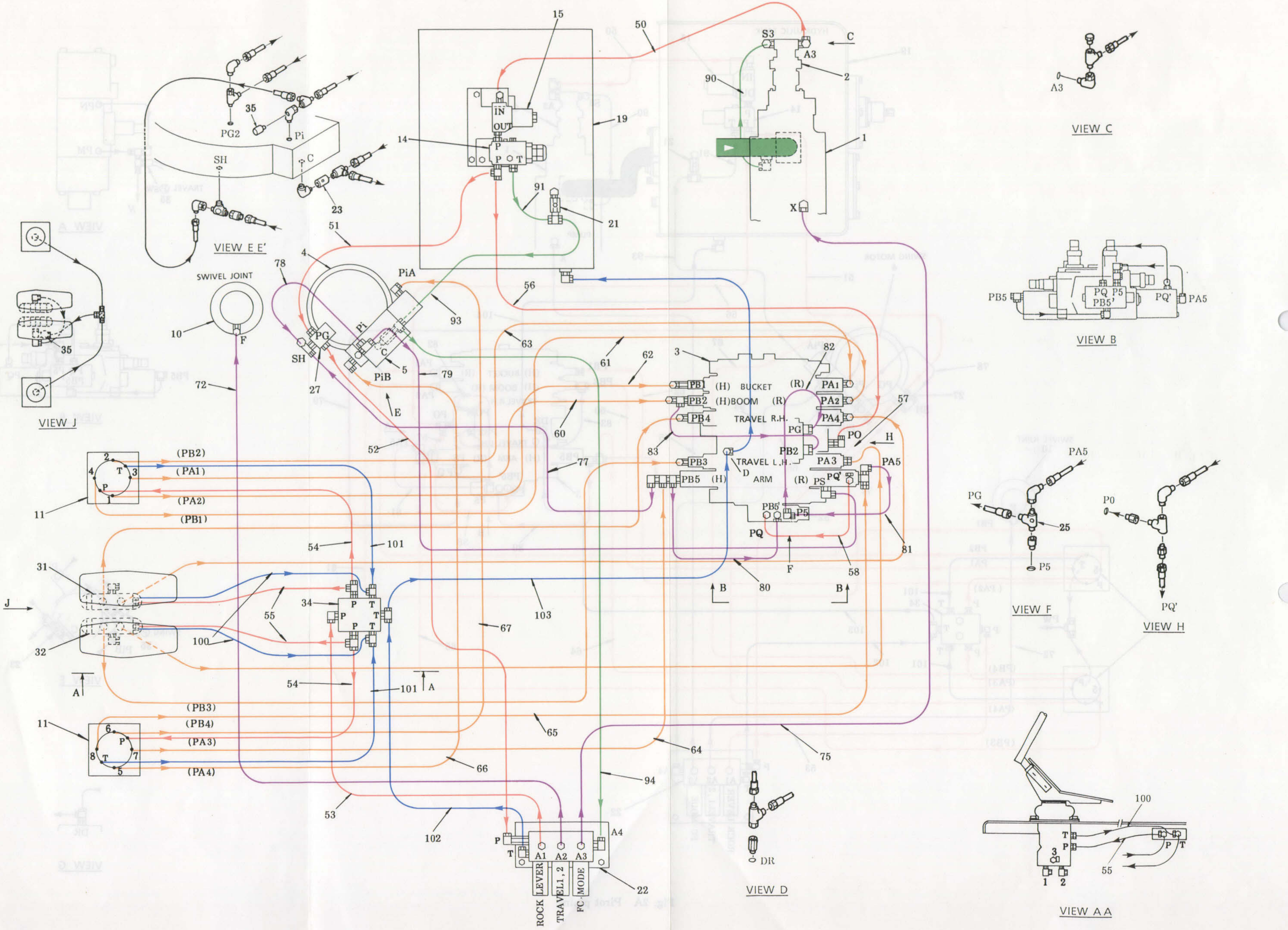

15
50
C
S3
A3
2
90
1
19
14
IN
OUT
P
P
T
91
21
X
VIEW C
A3
PB5
PQ
P5
PB5'
PQ'
PA5
VIEW B
35
PG2
Pi
SH
C
23
VIEW E E'
51
SWIVEL JOINT
10
F
78
4
PiA
93
PG
Pi
C
5
SH
27
PiB
79
56
63
61
62
3
82
PB1
(H)
BUCKET
(R)
PA1
PB2
(H)BOOM
(R)
PA2
PB4
TRAVEL R.H.
PA4
57
PG
PO
H
PB2
83
PB3
TRAVEL L.H.
D
PA3
PA5
PB5
(H)
ARM
(R)
PS
PQ'
PB5'
P5
PQ
F
81
58
80
B
B
60
77
52
E
72
35
VIEW J
11
2
4
T
3
P
1
(PB2)
(PA1)
(PA2)
(PB1)
54
101
31
J
34
P
T
P
T
P
T
55
100
32
103
67
54
101
A
A
11
6
P
8
T
7
5
(PB3)
(PB4)
(PA3)
(PA4)
65
64
75
66
94
53
102
P
T
A1
A2
A3
A4
22
ROCK LEVER
TRAVEL1, 2
FC-MODE
DR
VIEW D
PG
PA5
25
P5
VIEW F
P0
PQ'
VIEW H
100
T
P
3
1
2
55
P
T
VIEW A A

Fig. 2B Pirot piping

2. CONSTRUCTION

2.1 BACKHOE ATTACHMENTS

(1) Arm

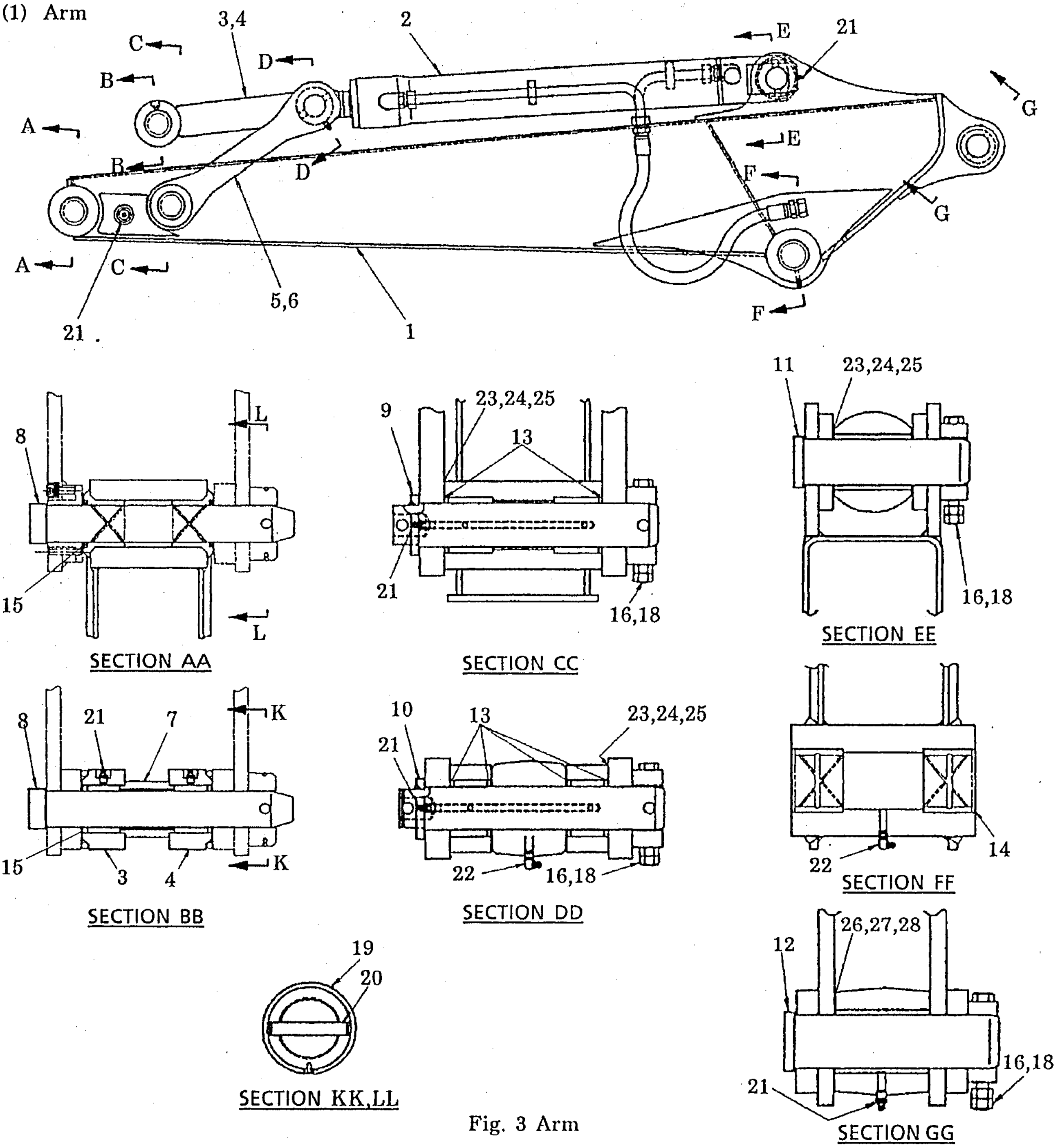
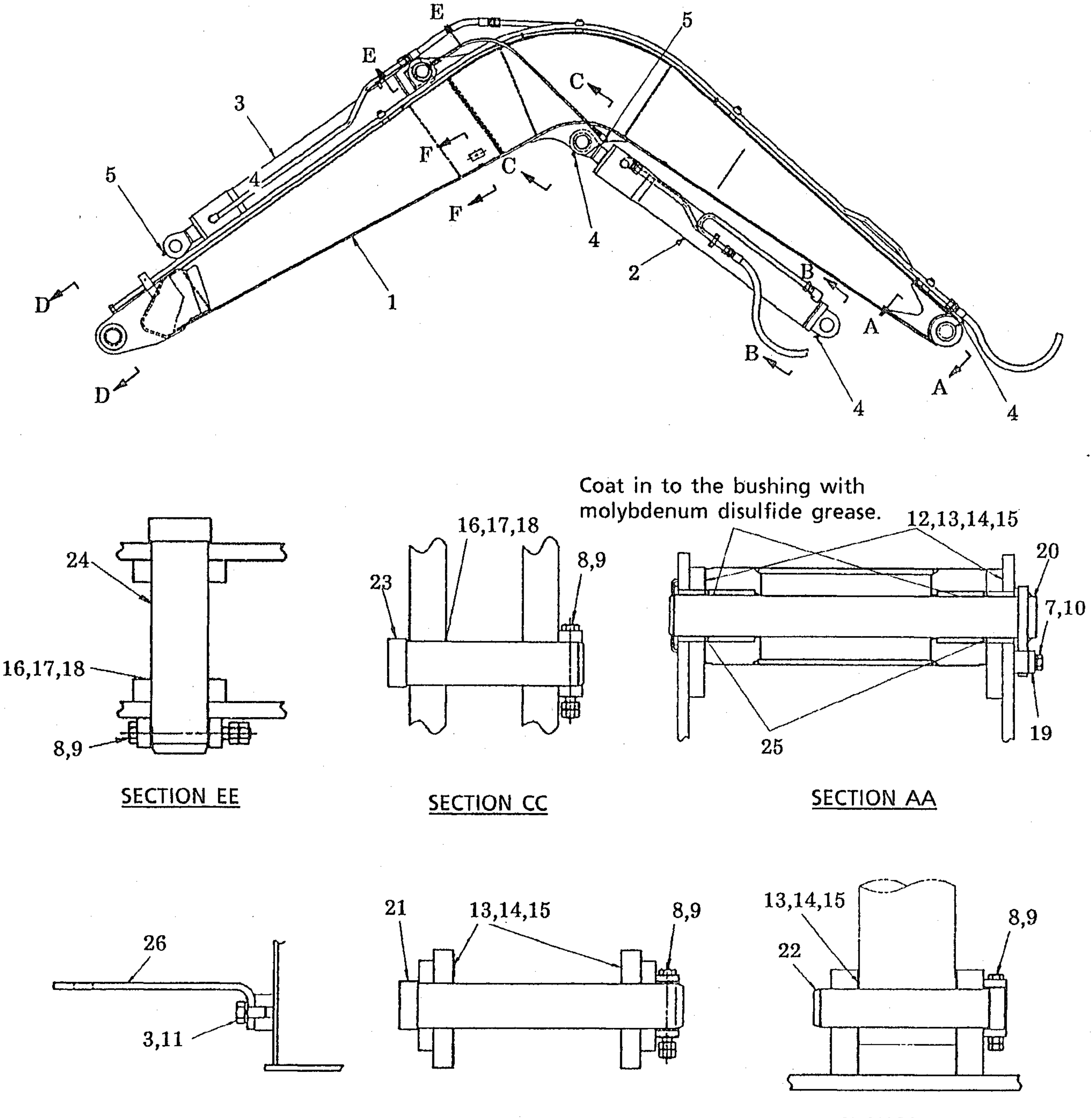

3,4
2
21
C
D
B
A
E
G
B
D
F
G
A
C
21
5,6
1
F
8
L
15
L
SECTION AA
9
23,24,25
13
21
16,18
SECTION CC
11
23,24,25
16,18
SECTION EE
8
21
7
K
15
3
4
K
SECTION BB
10
13
23,24,25
21
22
16,18
SECTION DD
22
14
SECTION FF
19
20
SECTION KK,LL
12
26,27,28
16,18
21
SECTION GG

Fig. 3 Arm

However, only necessary number of shims must be selected.

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
1	ARM	1	11	PIN	1	22	GREASE FITTING	2
2	BUCKET CYLINDER	1	12	PIN	1	23	SHIM t=1.2	3
3	BUCKET LINK	1	13	DUST SEAL	6	24	SHIM t=1.6	3
4	BUCKET LINK	1	14	DUST SEAL	2	25	SHIM t=2.3	3
5	IDLER LINK (RIGHT)	1	15	DUST SEAL	4	26	SHIM t=1.2	1
6	IDLER LINK (LEFT)	1	16	CAPSCREW	4	27	SHIM t=1.6	1
7	SPACER	1	18	NUT	8	28	SHIM t=2.3	1
8	PIN	2	19	RING	2			
9	PIN	1	20	PIN	2			
10	PIN	1	21	GREASE FITTING	6			

(2) Boom


E
E
5
3
4
C
5
F
C
F
4
1
D
D
2
B
B
A
A
4
4
Coat in to the bushing with molybdenum disulfide grease.
24
16,17,18
8,9
23
16,17,18
8,9
12,13,14,15
20
7,10
25
19
26
3,11
21
13,14,15
8,9
13,14,15
22
8,9

SECTION EE

SECTION CC

SECTION AA

SECTION FF

SECTION DD

SECTION BB

Fig. 4 Boom

However, only necessary number of shims must be selected.

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
1	BOOM	1	10	LOCKWASHER	2	18	SHIM t=2.3	2	26	BRACKET	1
2	BOOM CYLINDER	1	11	LOCKWASHER	1	19	PLATE	1			
3	ARM CYLINDER	1	12	SHIM t=0.9	1	20	PIN	1			
4	GREASE FITTING	4	13	SHIM t=1.2	4	21	PIN	1			
5	GREASE FITTING	2	14	SHIM t=1.6	4	22	PIN	1			
7	CAPSCREW	2	15	SHIM t=2.3	4	23	PIN	1			
8	CAPSCREW	4	16	SHIM t=1.2	2	24	PIN	1			
9	NUT	8	17	SHIM t=1.6	2	25	DUSTSEAL	2			

3. REMOVAL AND INSTALLATION OF ATTACHMENTS

3.1 REMOVING BUCKET

1) Operate the control lever and bring the bucket down to the ground so no load may be laid on the pin that links the bucket with the arm.
2) Remove the pin retaining ring and the pin from the bucket boss using a standard screwdriver, and pull out pin (A) (see Fig. 5).

☞
- If the pin is hard to come out, it indicates that the pin is loaded. Then operate the control lever to remove the load.
- Use care so as not to damage O ring between the arm and the bucket boss.

3) Operate the control lever so pin (B) between the bucket link and the bucket may not be loaded.
4) Remove the pin retaining ring and the pin from the bucket boss using a standard screwdriver, and pull out pin (B) (see Fig. 6).

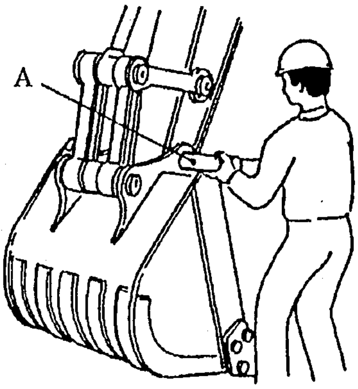


Fig. 5 Remove pin (A)

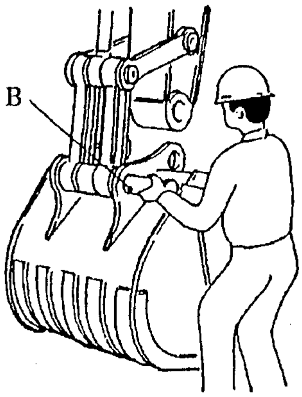


Fig. 6 Remove pin (B)

3.2 INSTALLING BUCKET (SEE FIG. 7)

Reverse the removing procedure, noticing the following cautions and steps.

1) Remove any contaminants from the welded portion of each structure, and check for cracks.
2) Check the bushings in the bores at the bucket bosses for wear and damage in accordance with "Maintenance Standards" provided later in this manual, and if necessary, replace them with new ones.
3) Check the dust seal for damage, and if damaged, replace with a new one.
4) Apply grease to the shank of the pin before inserting it.

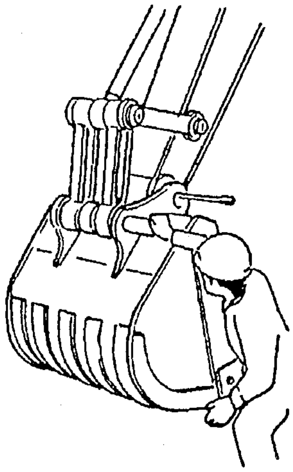


Fig. 7 How to install the bucket

☞ Installing the bucket link first facilitates installing the bucket.

⚠ Never put your finger in a pin hole when aligning the pin holes. Align them visually.

3.3 REMOVING ARM (SEE FIG. 8)

1) Place a sling in body (C) of the arm cylinder and lift it so as not to load pin (D).
2) Remove the capscrew and nut (E) that fasten pin (D), and draw out pin (D).
3) Place a wooden block under the cylinder and bring the cylinder down to it.
4) Disconnect all hydraulic hose joints and put a plug into each of them.
5) Bring pin (D) back into the arm, place a sling around pin (D) and lift it with a crane.
6) Remove the capscrew stopping the pin (F) that connects the arm and the boom, then remove the pin (F) by tapping on its opposite end.

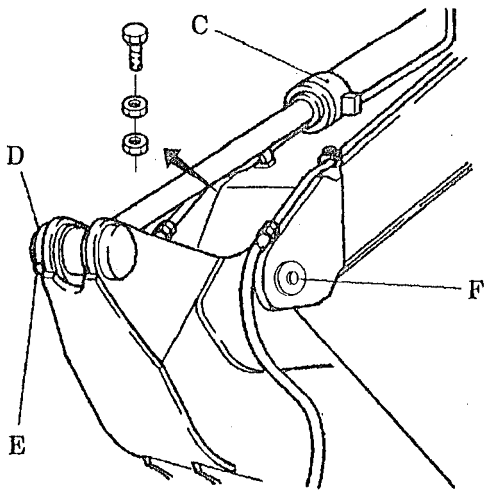


Fig. 8

3.4 INSTALLING ARM (SEE FIG. 8)

1) Place a sling around pin (D), lift it with a crane and bring it close to the boom connection to align pin holes.
2) Fit pin (F) into the joint between the arm and the boom.
3) Connect all hydraulic hose joints.
4) Remove the sling hanging pin (D) and lift arm cylinder body (C).
5) Link the rod side of the arm cylinder with the arm by means of pin (D).

☞

When inserting pins, coat grease over the shaft section.

3.5 REMOVING BOOM

1) Place a sling around boom cylinder (G), lift it and remove the capscrew and nut that fasten pin (H). (See Fig.9.)
2) Draw out pin (H), contract cylinder (G) to its minimum stroke and dismantle it.
3) Disconnect all tubes and hoses and put a plug into each opening
4) Disconnect electric wiring of head light.

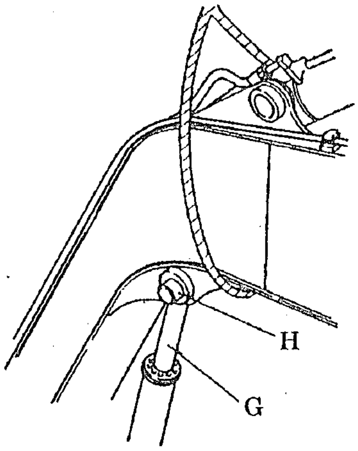


Fig. 9

5) Place a sling in the boom, lift it with a crane and remove the capscrew and plate fastening pin (J) that links the boom with the swing frame. Then draw out the pin (J) by tapping it from the opposite side.(See Fig. 10)

☞
- Take care not to damage the piston rod.
- When the cylinder is taken off the boom, always retract the piston rod.
- When lifting the boom, always lift the center of gravity. Lift it slowly and if the boom foot is twisted, correct it with a steel pry before removal.
- Boom removing work will be promoted if the cab is taken off first of all.

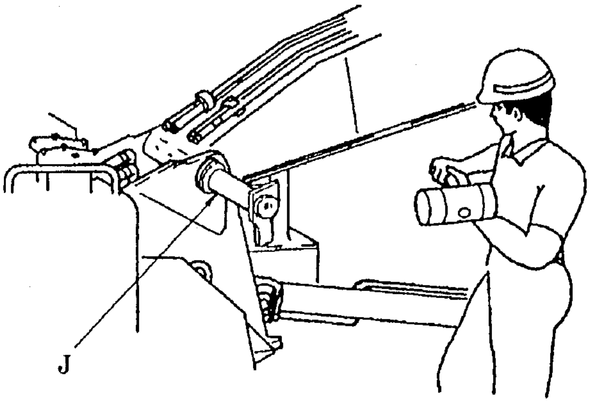


Fig. 10

3.6 INSTALLING THE BOOM (SEE FIG. 9 AND 10)

Install the boom by reversing the order of the steps for removal.

Lift the boom with a crane attached to the boom's center of gravity (the boom assembly weighs about 670kg (1500 lbs)), and fasten the boom foot. Install the boom cylinders and connect the hydraulic piping. Link the boom with the arm, and install the cylinders. After connecting the cables, check piping for oil leaks.

4. MAINTENANCE STANDARDS

4.1 CLEARANCE BETWEEN PINS AND BUSHING

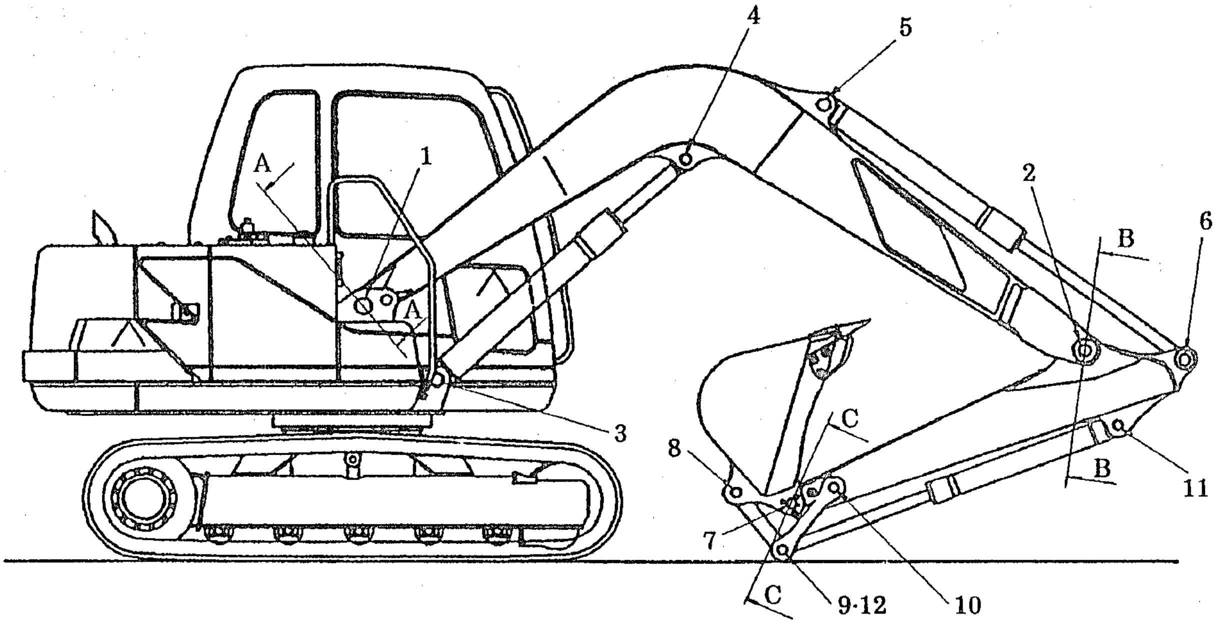


Fig. 11A

Standard Spec.

Table 4A

Unit: mm

(ft-in) No.	Item	Standard Value				Allowable Value	Remedy
		Pin Dia	Tolerance for pin O.D.	Tolerance for Bushing I.D.	Clearance		
1	Boom foot	Ø60 (Ø2.3622″)	−0.15 (0.0059″) ~ −0.21 (0.0083″)	+0.177 (0.0070″) ~ +0.043 (0.0017″)	+0.193 (0.0076″) ~ +0.387 (0.0152″)	2.0 (0.08″)	Replace bushing or pin.
2	Arm center						
3	Boom cylinder (Bottom side)			+0.25 (0.0098″) ~ +0.05 (0.0020″)	+0.20 (0.0079″) ~ +0.20 (0.0181″)		
4	Boom cylinder (Rod side)	Ø55 (Ø2.1654″)					
5	Arm cylinder (Bottom side)						
6	Arm cylinder (Rod side)						
7	Arm point	Ø50 (Ø1.9685″)		+0.189 (0.0074″) ~ +0.052 (0.0020″)	+0.202 (0.0080″) ~ +0.399 (0.0157″)		
8	Bucket link (Bucket connection)						
9	Bucket link						
10	Idler link (Arm connection)						
11	Bucket cylinder (Bottom side)			+0.25 (0.0098″) ~ +0.05 (0.0020″)	+0.20 (0.0079″) ~ +0.46 (0.0181″)		
12	Bucket cylinder (Rod side)						

4. MAINTENANCE STANDARDS

4.1 CLEARANCE BETWEEN PINS AND BUSHING

GRINDED PIN

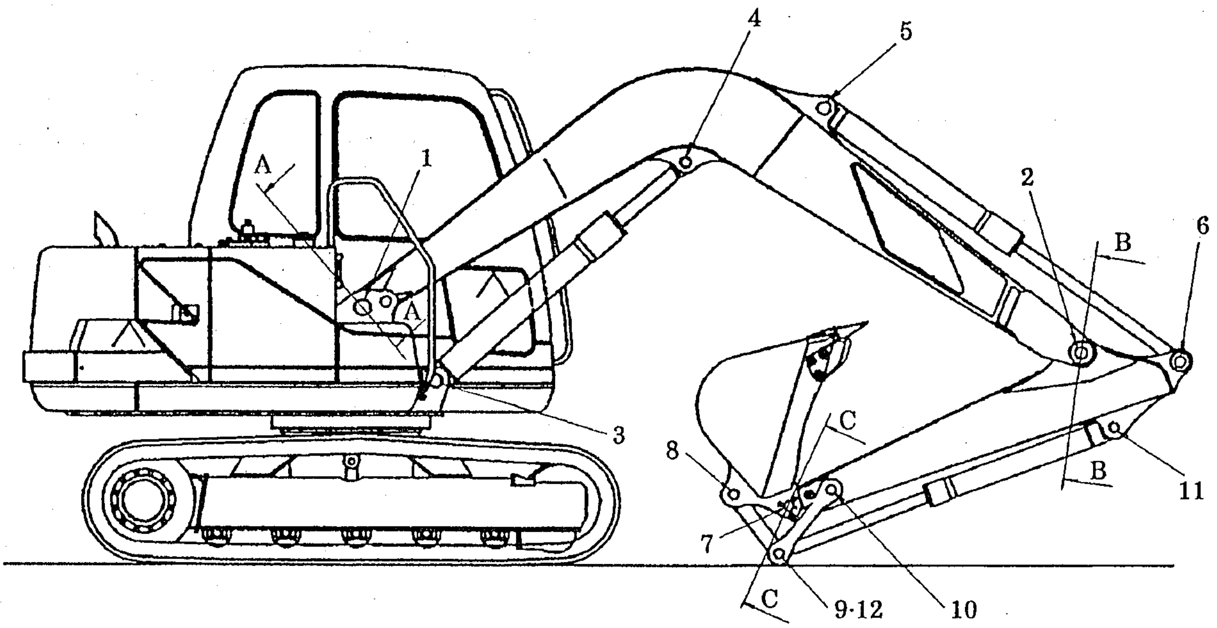


Fig. 11B

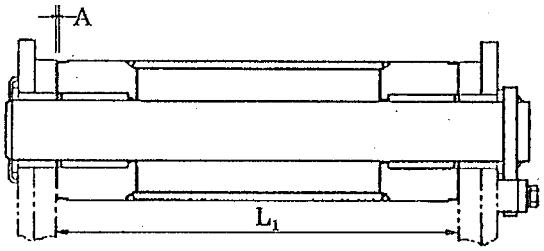
Standard Spec.

Table 4B

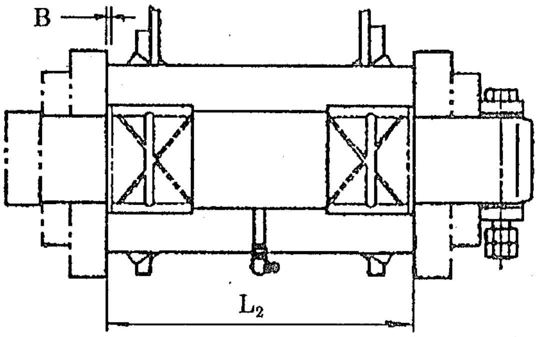
Unit: mm

(ft-in) No.	Item	Standard Value				Allowable Value	Remedy
		Pin Dia	Tolerance for pin O.D.	Tolerance for Bushing I.D.	Clearance		
1	Boom foot	Ø60 (Ø2.3622")	−0.05 (0.0020") ~ −0.09 (0.0035")	+0.177 (0.0070") ~ +0.043 (0.0017")	+0.093 (0.0037") ~ +0.267 (0.0105")	2.0 (0.08")	Replace bushing or pin.
2	Arm center						
3	Boom cylinder (Bottom side)			+0.25 (0.0098") ~ +0.05 (0.0020")	+0.10 (0.0039") ~ +0.55 (0.0217")		
4	Boom cylinder (Rod side)	Ø55 (Ø2.1654")					
5	Arm cylinder (Bottom side)						
6	Arm cylinder (Rod side)						
7	Arm point	Ø50 (Ø1.9685")	−0.15 (0.0059") ~ −0.21 (0.0083")	+0.189 (0.0074") ~ +0.052 (0.0020")	+0.202 (0.0080") ~ +0.399 (0.0157")		
8	Bucket link (Bucket connection)						
9	Bucket link						
10	Idler link (Arm connection)						
11	Bucket cylinder (Bottom side)		−0.05 (0.0020") −0.09 (0.0035")	+0.25 (0.0098") ~ +0.05 (0.0020")	+0.10 (0.0039") +0.34 (0.0134")		
12	Bucket cylinder (Rod side)		−0.15 (0.0059") −0.21 (0.0083")		+0.20 (0.0079") +0.46 (0.0181")		

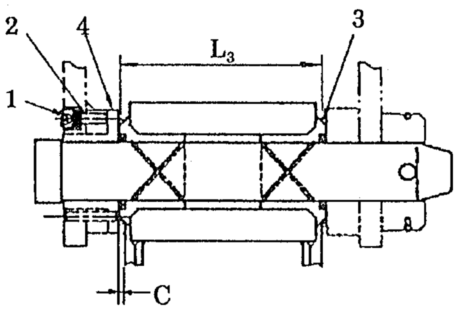
4.2 CLEARANCE IN THRUST DIRECTION OF BOOM, ARM AND BUCKET



BOOM FOOT SECTION



ARM CENTER SECTION



ARM POINT SECTION

1. SOCKET BOLT
2. SHIM
3. O RING
4. BUSHING

Fig. 12

Table 5

Unit: mm (in)

Item		Tolerance		Clearance		Adjust shims standerd value	Clearance allowable value
Boom foot section	Boom	L1	$400^{0}_{-0.2}$ $\left(15.748''^{\ 0}_{-0.008''}\right)$	A	2.0 (0.079″) ~ 4.2 (0.165″)	2 or under	4 (0.158″)
	Upper frame		$402^{+2.0}_{0}$ $\left(15.827''^{+0.079''}_{\ 0}\right)$				
Arm center section	Arm side	L2	214±0.2 (8.425″±0.008″)	B	1.8 (0.071″) ~ 4.2 (0.165″)	1 or under	2 (0.079″)
	Boom side		$216^{+2.0}_{0}$ $\left(8.504''^{+0.079''}_{\ 0}\right)$				
Arm point section	Arm side	L3	180±0.3 (7.087″±0.012″)	C	1.5 (0.059″) ~ 2.5 (0.0.98″)	1 or under	2 (0.079″)
	Bucket side		182±0.2 (7.165″±0.008″)				

4.3 ADJUSTING CLEARANCE BETWEEN BUCKET AND ARM (SEE FIG.13)

(1) Clearance adjusting procedure

1) Shift O ring (3) to the boss on the arm side, using a spatula or something.
2) Measure clearance (A1).
3) Loosen three socket screws (1), remove shims (2), tighten three socket screws (1) evenly, and press bushing (5) and tighten socket screws (1) till clearance (B) gets to 0.5 ~1.0mm (0.02~0.04in) (provided clearance (C) on the opposite side is in close contact).
4) Measure clearance (A2).
5) The thickness of a single shim (2) is 1mm (0.04in).
6) Clearance (A2) less the initaially measured clearance (A1) is the thickness of shims (2) to be taken off.
7) Confirm that clearance (B) falls within the standard value.
8) Fit O ring (3) to its original position.

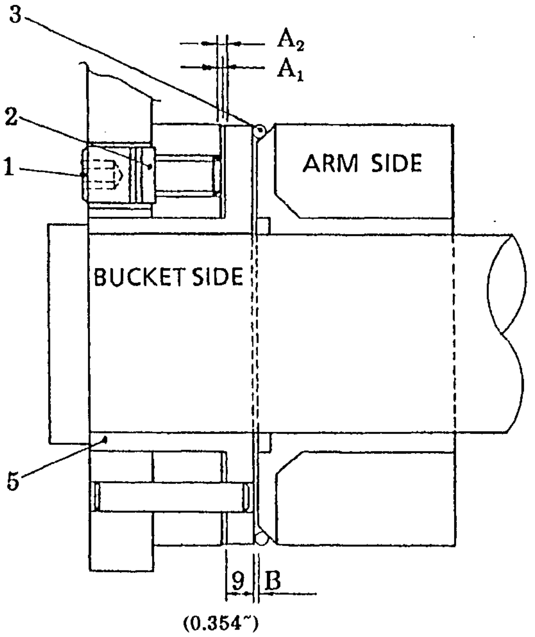


Fig. 13

☞
- Use care so as not to damage O ring (3) when shifting O ring (3) with a spatula.
- When removing shim (2) and extruding bushing (5) to the rights with three socket screws (1), do not tighten them too hard and take care so clearance (C) is not within the standard value.
- Inspect clearances every 120 hours in normal operation. In case of special operation perform inspection earlier than usual and adjust them as required.

BooK code No. S5LE2206E

KOBELCO

SHOP MANUAL SK60

CONTROL SYSTEM

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LE 22

KOBE STEEL, LTD.

Applicable Machines
LE-11001~

		NORTH AMERICA			NORTHEN EUROPA			EUROPA					CUSTOMER'S COUNTRY							
	PAGE	KAI			FINLAND	NORWAY	SWEDEN	DENMARK	ENGLAND	HOLLAND BELGIUM PORTUGAL	AUSTRIA	SWISS	CENTRAL SOUTH AMERICA	NEW ZEALAND	AUSTRALIA	TAIWAN	CHINA	NEAR MIDDLE AFRICA		
SELECT PAGE	2	B			B	B	B	B	B	B	B	B	A	A	A	A	A	A		
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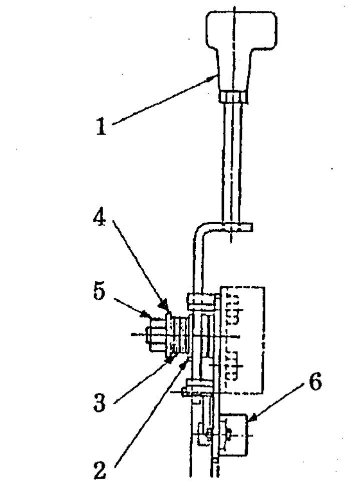
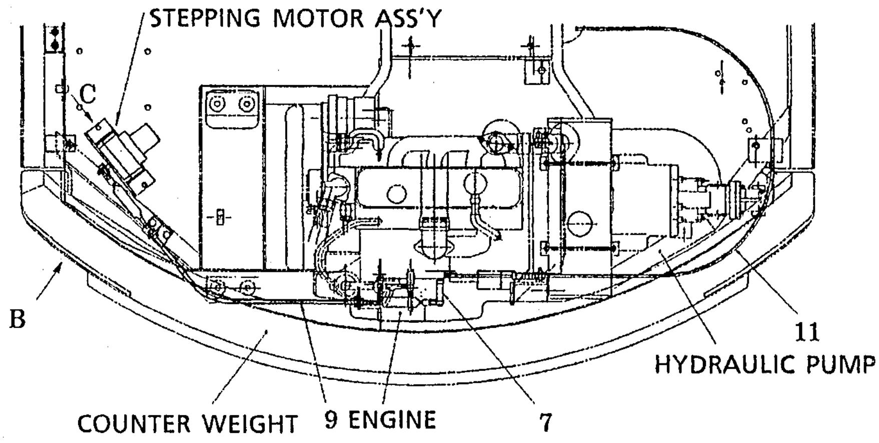
Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE2206E K

1. ENGINE CONTROL INSTALLATION

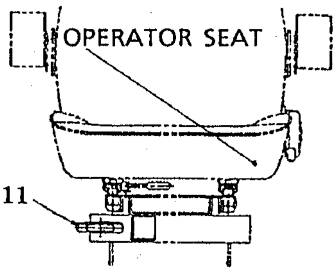
1.1 CONSTRUCTION

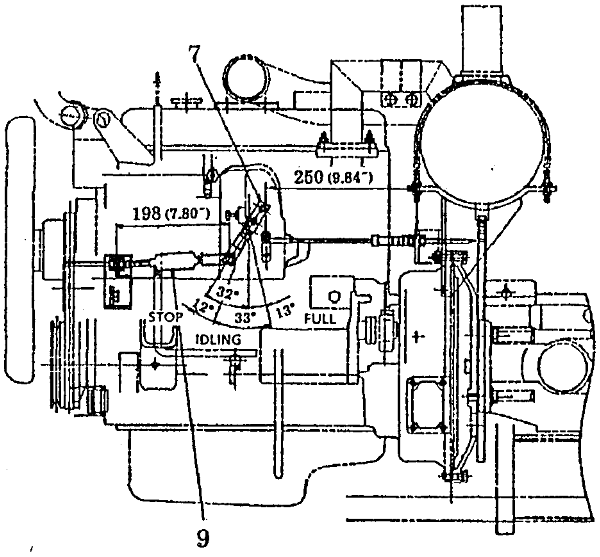


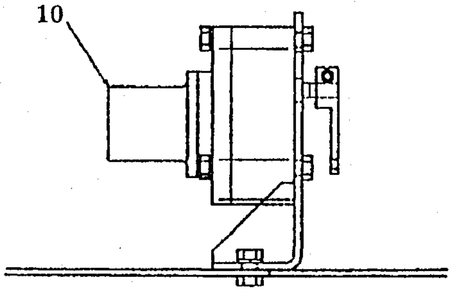
THROTTLE LEVER ASS'Y


STEPPING MOTOR ASS'Y
C
B
11
HYDRAULIC PUMP
COUNTER WEIGHT
9 ENGINE
7

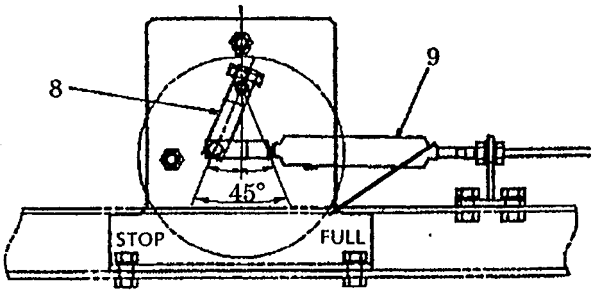
CONTROL CABLE ROUTING


OPERATOR SEAT
11


7
250 (9.84")
198 (7.80")
32°
12°
33°
13°
STOP
IDLING
FULL
9



(VIEW C)


8
9
45°
STOP
FULL

(VIEW B)

STEPPING MOTOR AND CONTROL CABLE MOUNTING

Fig. 1 Engine control ass'y

No.	NAME	Q'ty	No.	NAME	Q'ty
1	THROTTLE LEVER	1	7	ENGINE GOVERNOR LEVER	1
2	WASHER	1	8	LEVER	1
3	WASHER	6	9	CONTROL CABLE ROUTING	1
4	WASHER	1	10	STEPPING MOTOR	1
5	U NUT	1	11	CONTROL CABLE (EMERGENCY STOP OF ENG.)	1
6	POTENTIOMETER	1			

1.2 SUMMARY OF ENGINE CONTROL

The engine revolution when the engine is running is changed by turning potentiometer (6) mechanically by means of throttle lever (1).

The potentiometer transmits an electric signal proportionate to rotating angles to the controller.

The controller then reads an electric signal from potentiometer (6) , sends it out to stepping motor (10) to run stepping motor (10). This oscillates lever (8) fixed to the output shaft of stepping motor (10) and actuates engine governor lever (7) connected to the tip of the lever via control cable (9).

There are two modes for stopping the engine.

Normally, when the ignition key is turned to the OFF position, the stepping motor moves to the engine stop position, stopping the engine.

In an emergency, such as if the normal engine stopping mechanism fails, pulling the lever beneath the seat, which is the control cable (11) connected directly to the injection pump governor lever, moves that lever to the engine stop position, stopping the engine.

1.3 FUNCTION AND OPERATION OF STEPPING MOTOR

The functions of the stepping motor consist of the following four items.

(1) Operation controlled by potentiometer
The position to which the throttle lever, located on the instrument panel, is moved is read via the potentiometer (6), and is converted to an electrical signal to operate the stepping motor (10). The stepping motor actuates the engine governor via the lever and the control cable.

(2) Stopping the engine
When the ignition key is turned to the OFF position, the stepping motor moves to the engine stop position, stopping the engine.In the event that the engine cannot be stopped in a normal way due to some problem with the controller, pull the control cable (11) for emergency engine stop provided beneath the operator's seat.

(3) Work mode selection
When the K.P.S.S. mode selector switch is changed, the stepping motor moves the lever to the position corresponding to the engine speed selected. The throttle lever or mode selector switch, whichever selects the lower engine speed, takes precedence over the other.

(4) Automatic deceleration
If a certain length of time passes after operating lever (1) is brought to neutral by the auto accel select switch "ON", the engine runs at a decel revolution.

2.1 CONSTRUCTION

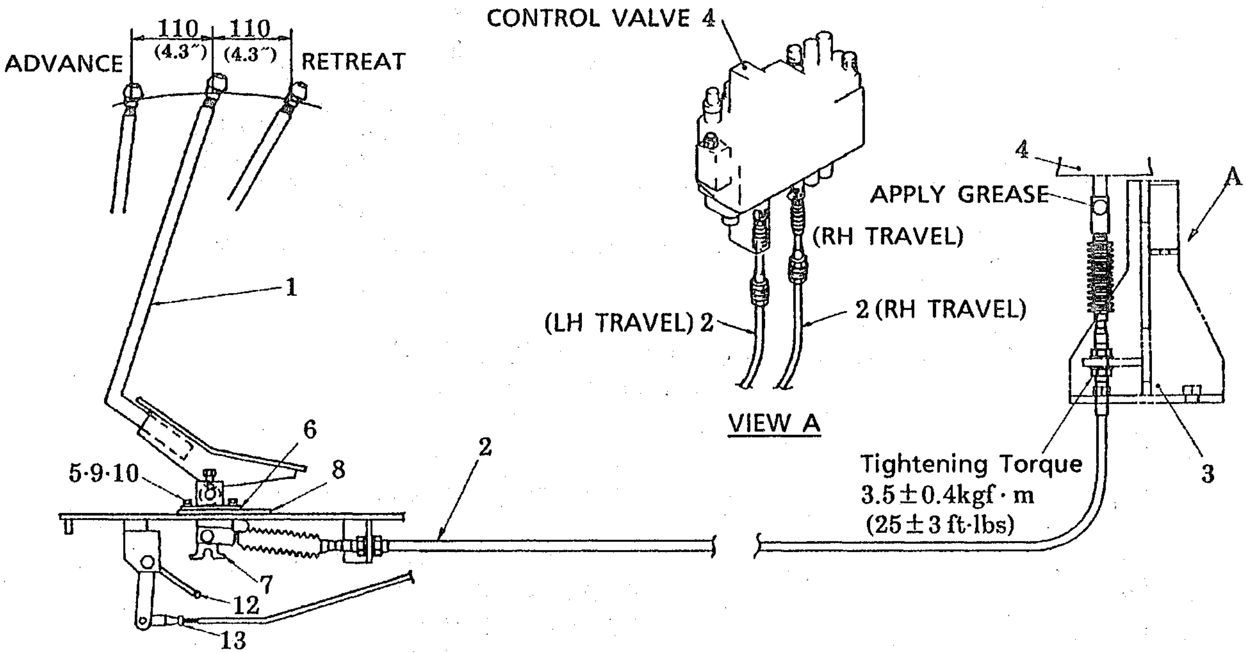


Fig. 2 Travel control

No	NAME	Q'ty	No	NAME	Q'ty
1	TRAVEL CONTROL LEVER	2	8	BRACKET	2
2	CONTROL CABLE	2	9	LOCK WASHER	4
3	BRACKET	2	10	WASHER	4
4	CONTROL VALVE	1	11	CONTROL BOX (Fig. 4)	2
5	CAPSCREW	4	12	LOCK PIN	1
6	PLATE (FOR STOPPER)	2	13	NUT	1
7	LEVER	2			

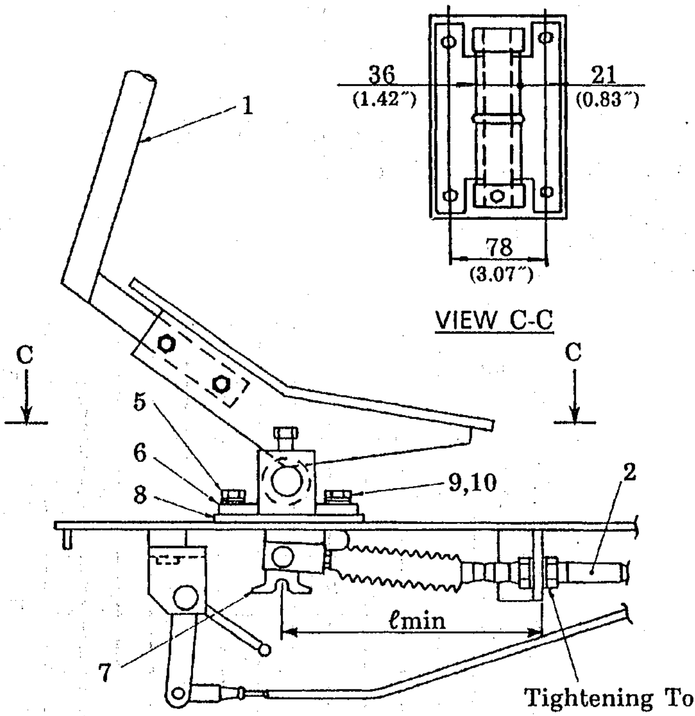


Fig. 3 Travel lever unlocked

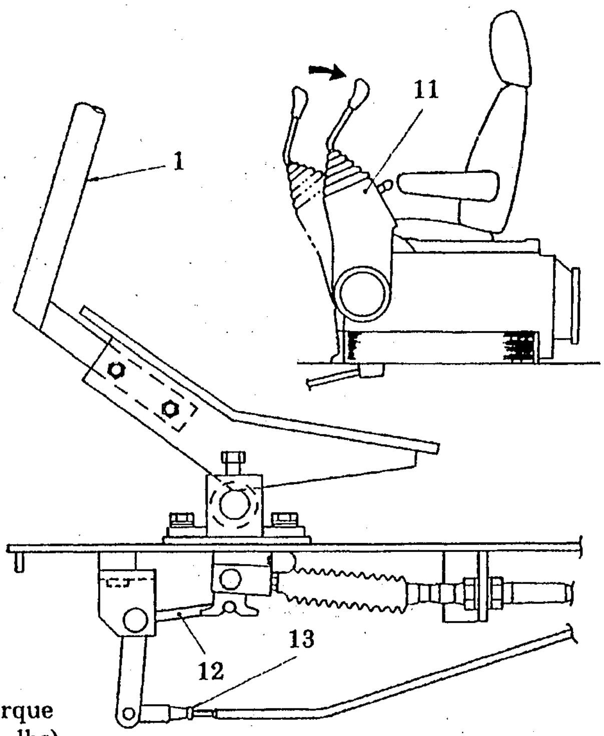


Fig. 4 Travel lever locked

2.2 OUTLINE

(1) Travel control system

1) The travel control consists of travel control lever (1) directly connected to the spool of control valve (4) by means of control cable (2) to transmit the movement of travel control lever (1) (together with pedal operation) to the spool of control valve (4)).

2) Plate (for stopper) (6) is provided on bracket (8) of travel control lever (1) so as to match the stroke of travel control lever (1) to the stroke of the control valve spool.

(2) Procedure for adjusting travel control lever

1) Temporarily fasten bracket (8) of travel control lever (1) so lever (7) stands upright, adjust and fix the dimension ℓmm of control cable (2) and make sure once again that lever (7) is upright. Then loosen two capscrew (5) on one side of bracket (8) and fasten plate (6) at a position 21mm (0.8 in) away from the center of the screwed hole and in parallel with the shaft. Fasten another side of bracket (8) at 21mm (0.8in) away from the same point and in parallel with the shaft, the same way as the other side.

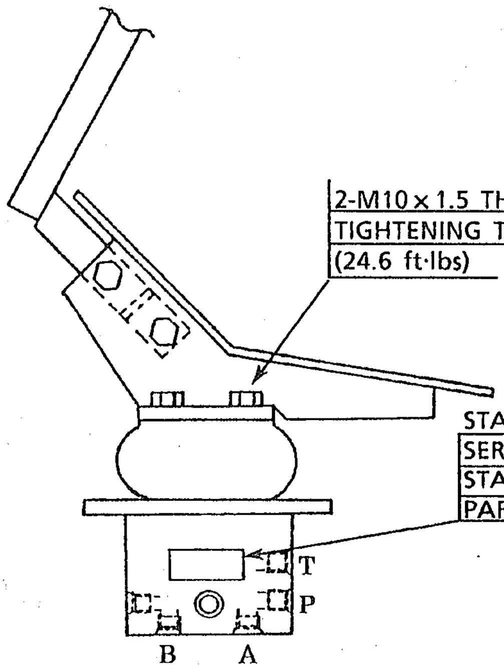
2) The travel of lever (7) is 12mm (0.5in) back and forth.

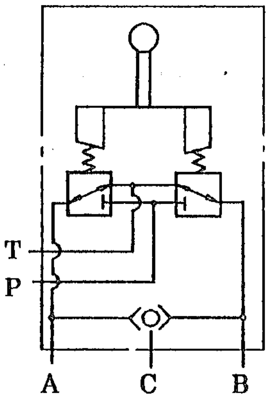
3) Place the travel control lever (1) in neutral, and adjust nut (13) so that the lock pin (12) is engaged in the lock notch in the travel control lever (1) when the left control box (11) is pulled back (in the direction of the arrow). Confirm that the lock pin (12) becomes disengaged from the lock notch when the control box (11) is returned to its original position. (See Fig. 4)

☞ The minimum bending radius of control cable (2) should be 200mm (7.9in) or over.

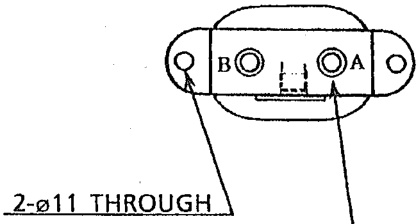
2. TRAVEL CONTROL SYSTEM (PILOT VALVE SPEC.)

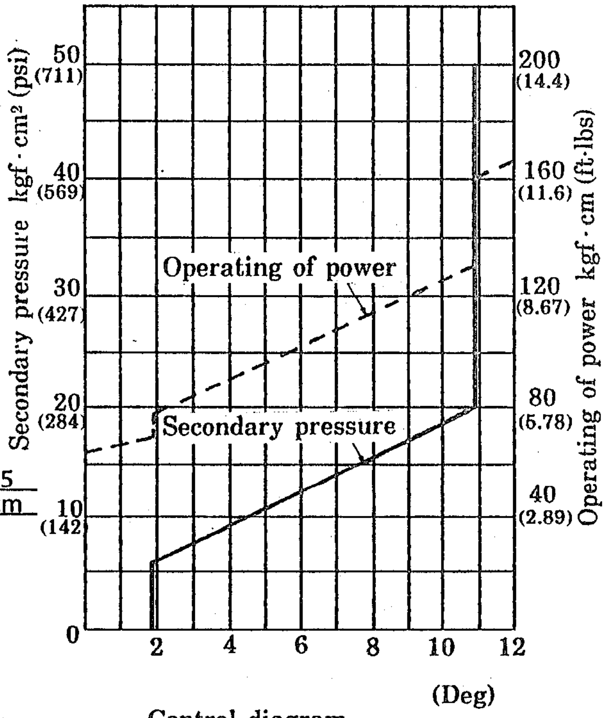
2.1 GEMERAL VIEW


2-M10×1.5 THREAD DEPTH 15
TIGHTENING TORQUE 340 kgf·cm
(24.6 ft·lbs)
STAMPING OF MODEL NAME &
SERIAL NO.
STAMPING OF CUSTOMER'S
PART NO.
T
P
B
A



HYDRAULIC SYMBOL


B
A
2-ø11 THROUGH
3-PH1/4 DEPTH 12
JIS B 2351 O-RING SEAL
SPOT FACING DIA. ø24 DEPH 0.5
TIGHTENING TORQUE 370 kgf·cm
(26.7 ft·lbs)



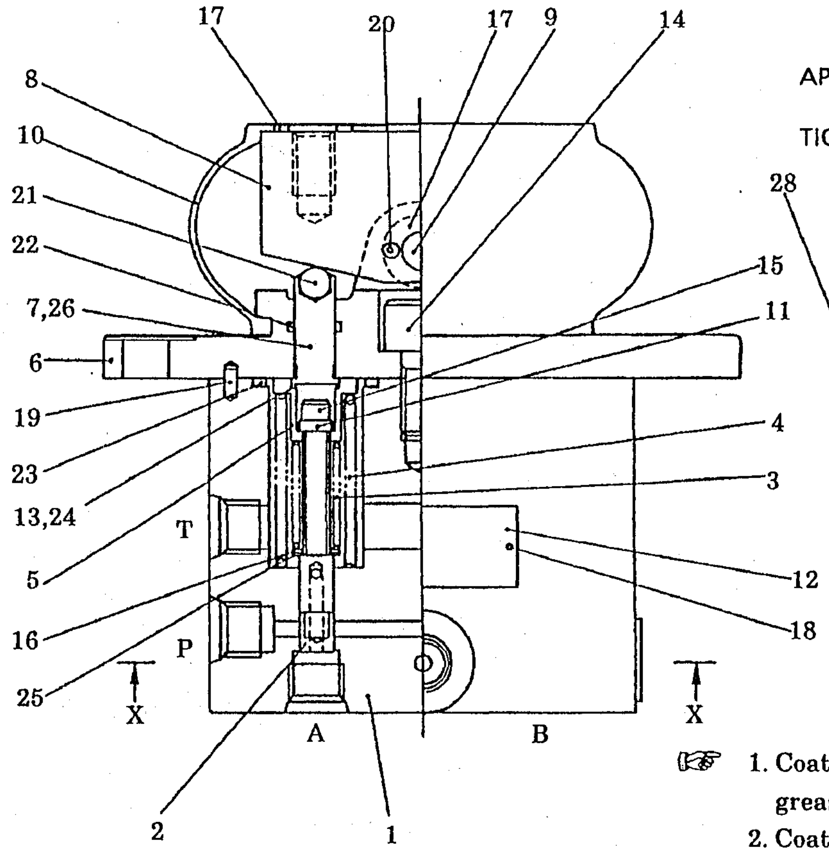
Control diagram

Fig. 5 Outo side view of travel pilot valve

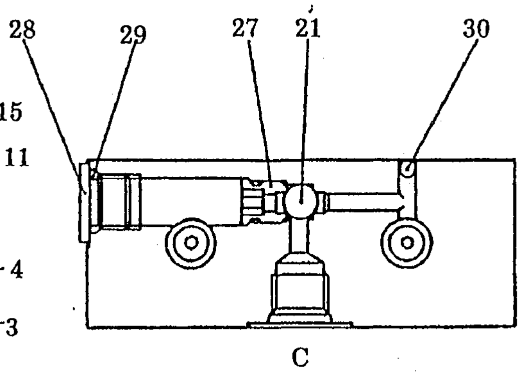
2.2 MAJOR SPECIFICATIONS

Item		Model RCV8CC1007
Max. pressure	kgf · cm² (psi)	50 (711)
Rated flow	ℓ/min (gaℓ/min)	10 (2.64)
Weight	Kg (lbs)	4 (8.82)

2.3 CONSTRUCTION



APPLY LOCKTITE #1306
AT ASSEMBLLY.
TIGHTENING TORQUE 1.5kgf·m (11ft·lbs)



X section

☞ 1. Coat the moving part of pin (9) with grease type rust preventive.
2. Coat steel ball (21) with grease.

2.4 OPERATION CONTROL SYSTEM

1) Travel operation

The travel operation method of the wrist spec. machine uses the secondary pilot pressure of the pilot valve direct-coupled to the bottom of the travel lever.

If the travel lever is actuated, the secondary pilot pressure comes out of port 1 or 2 of the valve and actuates the travel spool of the main control valve.

2) Auto accel signal

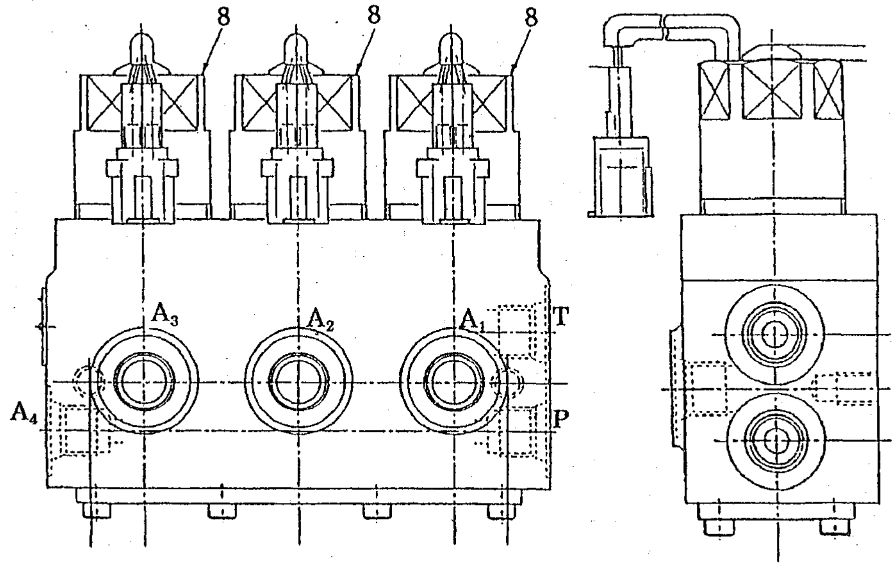
If an auto accel signal or the secondary control pressure produced by travel action is high-pressure selected, it goes out of port 3 of the valve, enters port PIT of the independent travel valve via the orifice block and acts upon the pressure switch to perform auto acceleration action.

No	NAME	Q'ty	No	NAME	Q'ty
1	BODY	1	16	WASHER	2
2	SPOOL	2	17	WASHER	4
3	SPRING	2	18	SCREW,RIVET	2
4	SPRING	2	19	PIN,SPRING	2
5	SLEEVE	2	20	PIN	2
6	COVER	1	21	BALL	3
7	ROD,PUSH	2	22	O-RING	2
8	CAM	1	23	O-RING	2
9	PIN	1	24	SHIM	2
10	BOOT	1	25	SHIM	2
11	COLLAR	2	26	PUSH ROD ASS'Y	2
12	NAME-PLATE	1	27	SEAT	1
13	SHIM	2	28	PULG	1
14	CAPSCREW	1	29	O-RING	1
15	BOLT,FLANGE	2	30	BALL	1

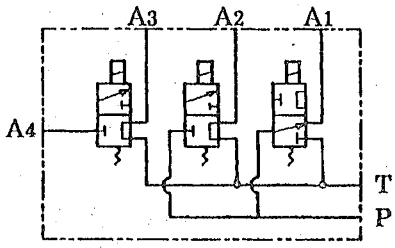
3 WORK CONTROL SYSTEM

3.1 SOLENOID VALVE (Lever lock, Travel speed, Mode changeover)

3.1.1 CONSTRUCTION



No	NAME	Q,ty
1	CASING	1
2	O RING	3
3	SPOOL	1
4	SPOOL	2
5	SPRING	3
6	COVER	1
7	SOCKET HEAD BOLT	8
8	SOLENOID	3



HYDRAULIC SYMBOLS

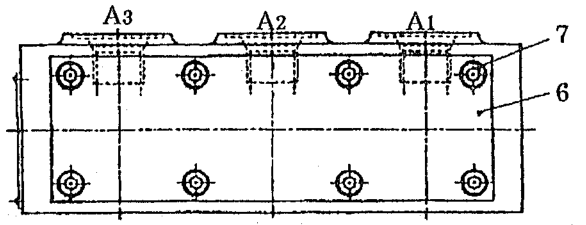


Fig. 5 External view of solenoid valve block

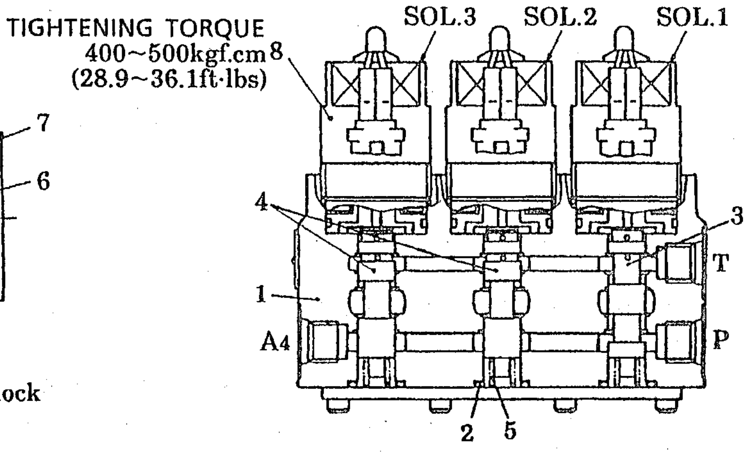


Fig. 6 Cross-section of solenoid valve block

3.1.2 OPERATION

This valve displays the following functions when three solenoids SOL.1, SOL.2 and SOL.3 is excited and ports A1, A2, and A3 are changed over.

(1) Solenoid SOL.1 ····· Lever lock action

When the control stand (lefthand)is in the operating position, the switch is turned on, whereupon the primary pilot pressure of port P connects with port A1 and is admitted to the pilot valve. When the control stand is brought to the lever lock position, the switch is turned off, whereupon the path from port P is closed and port A1 connects with tank port T. This prevents all pilot valves for the operating device from operating. On that occasion, the travel control lever is locked as a locking means that interlocks with the

Table 1

Item	Spec.		
Max. pressure	50kgf/cm^2 (711 psi)		
Max. flow and pressure loss (viscosity20 cst)	Flow direction	Max. ℓ/min flow (gal/min)	Press.kgf/cm^2 loss (psi)
	$P \rightarrow A_1$	16 (4.2)	5 (71.1) max.
	$P \rightarrow A_2$	1.2 (0.32)	5 (71.1) max.
	$A_2 \rightarrow T$	1.2 (0.32)	5 (71.1) max.
	$A_4 \rightarrow A_3$	1.2 (0.32)	5 (71.1)max.
	$A_3 \rightarrow T$	1.2 (0.32)	5 (71.1)max.
Leak rate	500cc/ min (30.5 cuin)		
Solenoid	Rated voltage		DC24V
	Voltage variation range		20.4 ~ 27.6V

movement of the control stand operates.

(2) Solenoid SOL.2 ···· Travel 2-speed command
If the "hare and tortoise" sign on the 2-speed travel switch is depressed, the primary pilot pressure connects with port A2 to form a travel motor 2-speed changeover signal circuit.

(3) Solenoid SOL.3 ···· Mode changeover command
When the operation mode switch is turned to the FC mode, the primary pilot pressure connects with port A3 to make the max. flow cut signal circuit for the pumps.

4. MAINTENANCE STANDARDS

4.1 ENGINE CONTROL INSTALLATION

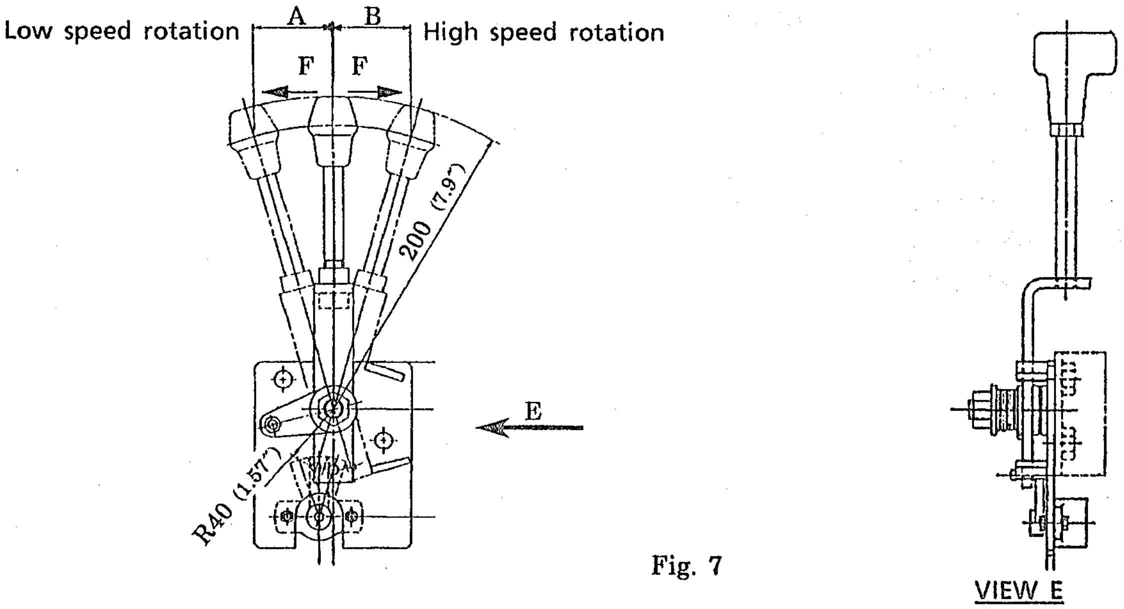

Low speed rotation
A
B
High speed rotation
F
F
200 (7.9")
R40 (1.57")
E
VIEW E

Fig. 7

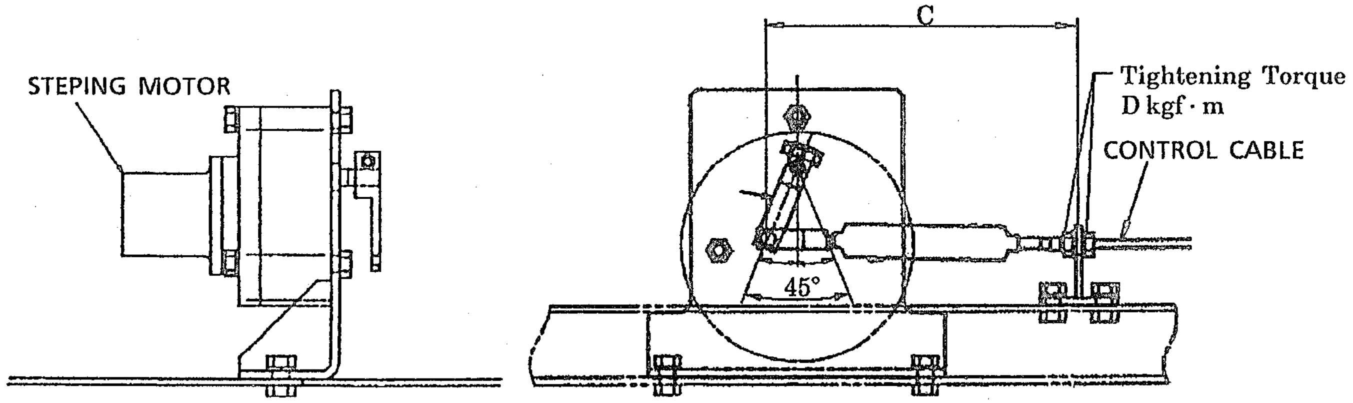

STEPING MOTOR
C
Tightening Torque
D kgf · m
CONTROL CABLE
45°

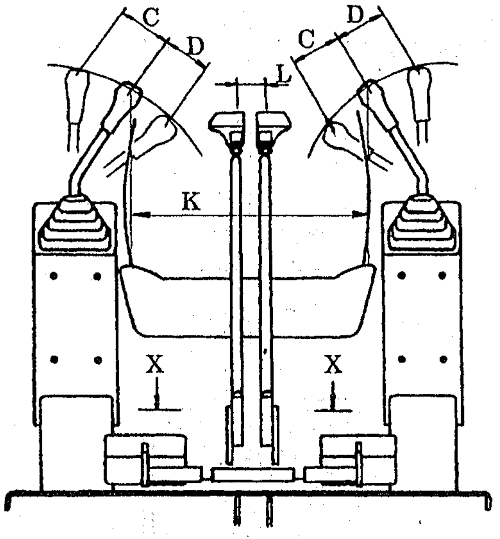
Fig. 8

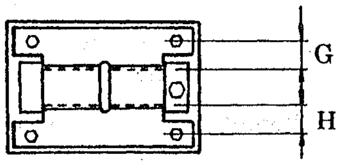
Procedure for measuring lever operation force
Place a spring balance on the lever ball and measure the operating force when the engine is at high idling speed.

Unit : mm (in) kgf · m (ft·lbs)

Symbol	Item	Standard value	Remarks
A	Throttle lever stroke	50 (1.97")	Adjust
B		50 (1.97")	
C	Mounting dimension of control cable	242 (9.53")	
D	Nut tightening torque	3.5±0.4 (25±3 lbs)	
F	Operating force of throttle lever	2.5±0.5 (18±4 lbs)	

4.2 OPERATION / TRAVEL CONTROL LEVER





VIEW X

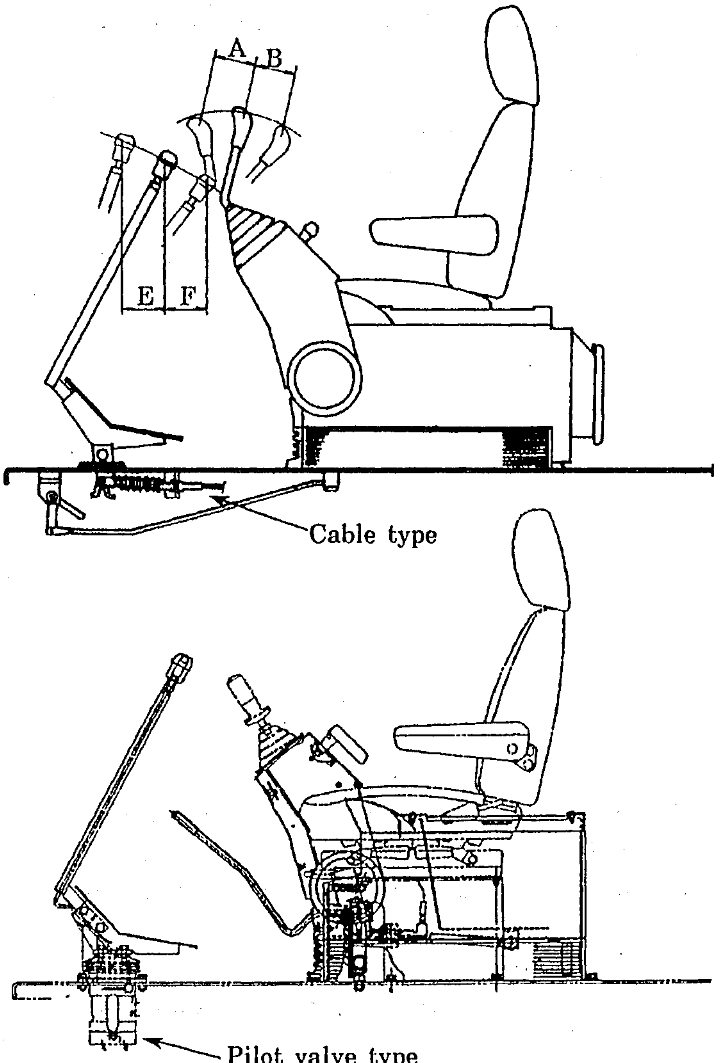


Fig.9

Precedure for measuring lever operation force
Set a balance to the engine, high idle, cylinder stroke end and lever ball sections and measure the operating forces at full stroke. (Engine stops at travel operaton only.)

Table 3

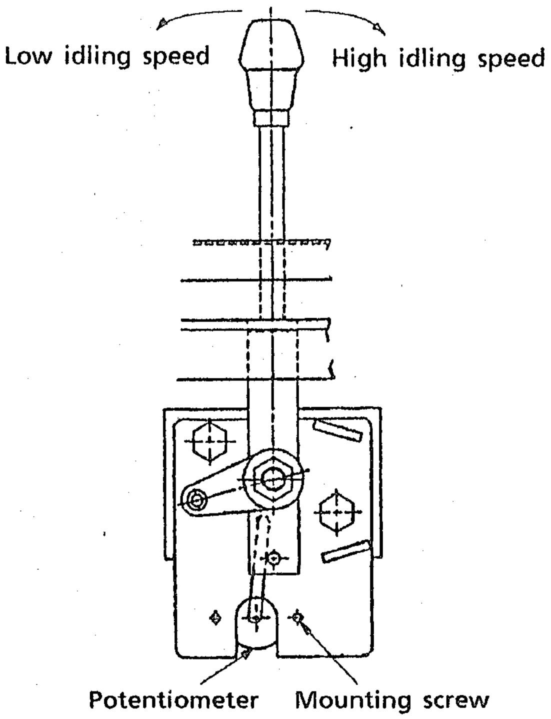
Unit : mm (in)

Symbol	Item	Standard value	Remarks
A , B	Back.and.force direction of operation control lever stroke	120±24 (4.72″±0.94″)	Boom and arm
C , D	LH/ RH direction of operation control lever stroke	120±24 (4.72″±0.94″)	Bucket and swing
E , F	Travel control lever stroke	130±25 (5.12″±0.98″)	Travel
G	Adjusting travel control lever stopper	21 (0.83″)	
H		21 (0.83″)	
K	Center.to.center distance when operation control lever is neutral	484 (19.06″)	
L	Center.to.center distance of travel control lever	50 (2.0″)	
	Operating force of operation control lever kg (lbs)	2±0.4 (4.4±0.9)	
	Operating force of travel control lever kg (lbs)	2±0.4 (4.4±0.9)	

4.3 ADJUSTING THE POTENTIOMETER

Connect a (9V) dry-cell battery to the potentiometer as shown in figure 12, and measure voltage with a tester.

☞ The reference voltage is 0V for both high and low idling speed.



Low idling speed
High idling speed
Potentiometer
Mounting screw

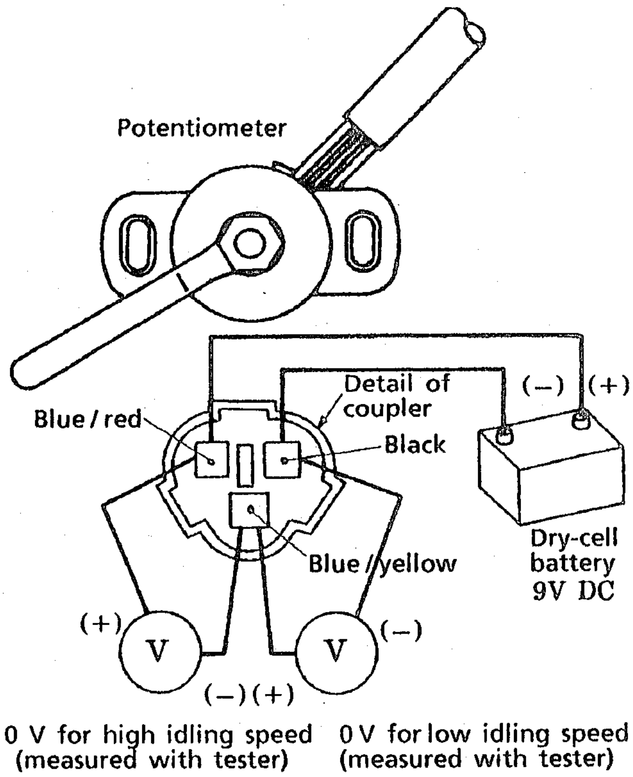
Fig. 10 Mounting position of potentiometer

With the potentiometer temporarily installed on the throttle lever, move the throttle lever to the low idling speed position, and confirm that the voltage is 0 V (when the battery is connected as shown in figure 11).

If the voltage is not zero, adjust the potentiometer to read 0 V.

With the throttle lever moved to the high idling speed position, make the same adjustment.

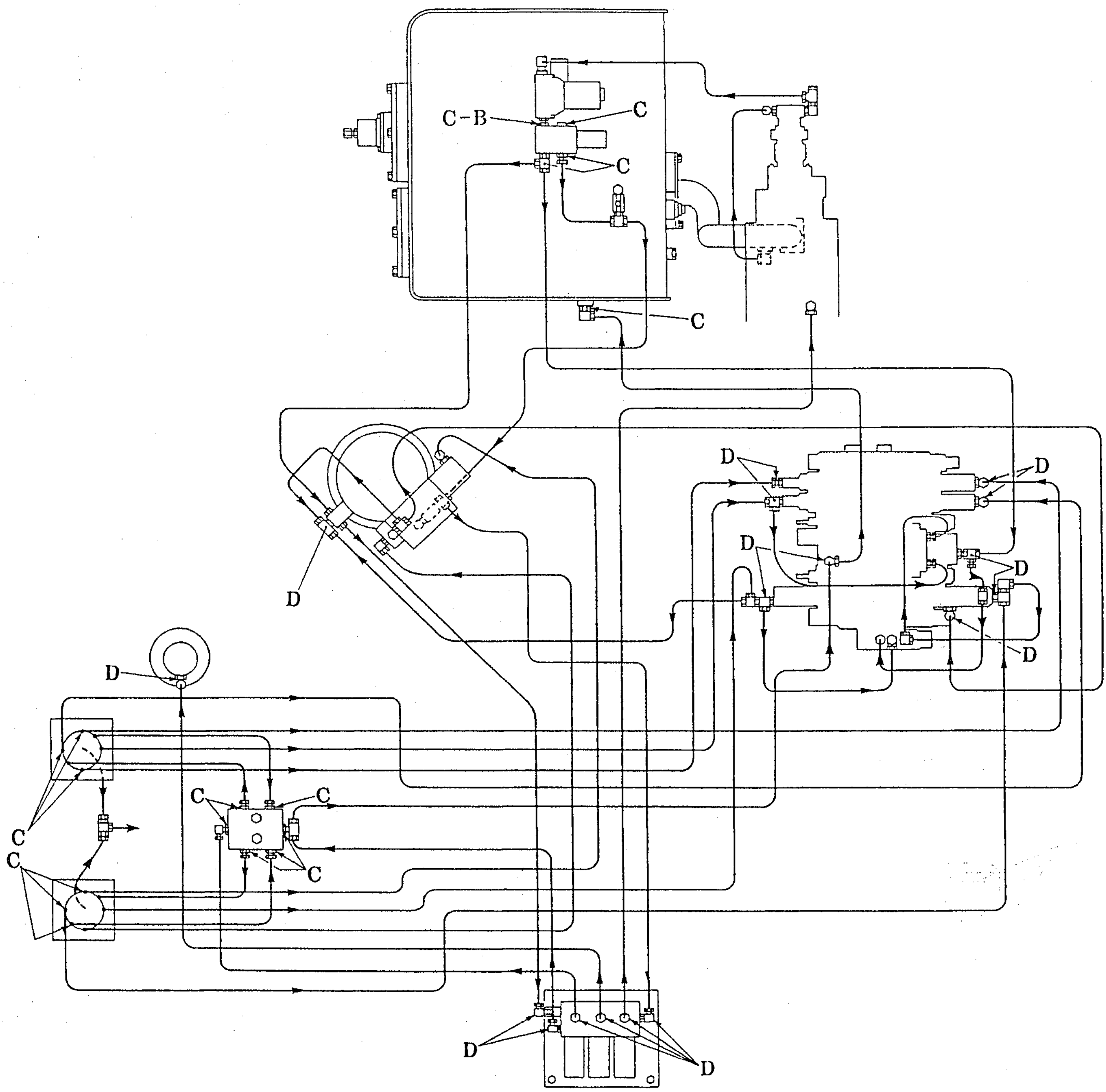
After these adjustments, tighten the mounting screws to fix the potentiometer.



Potentiometer
Detail of coupler
(−)
(+)
Blue / red
Black
Blue / yellow
Dry-cell battery 9V DC
(+)
V
V
(−)
(−)(+)
0 V for high idling speed (measured with tester)
0 V for low idling speed (measured with tester)

Fig. 11 Points across which to measure with tester

4.4 O RING PORT TIGHTENING TORQUE (LONG LEVER)



C−B
C
C
C
D
D
D
D
D
D
D
C
C
C
C
C
D
D

Fig. 12A

Table 4 Unit : kgf·m (ft·lbs)

Symbol	Size	O ring port tightening torque
B	PF 1/2	10.0~12.0 (72~86)
C	PF 3/8	7.0~8.0 (50~57)
D	PF 1/4	3.5~3.9 (25~28)

O RING PORT TIGHTENING TORQUE
(WRIST CONTROL)

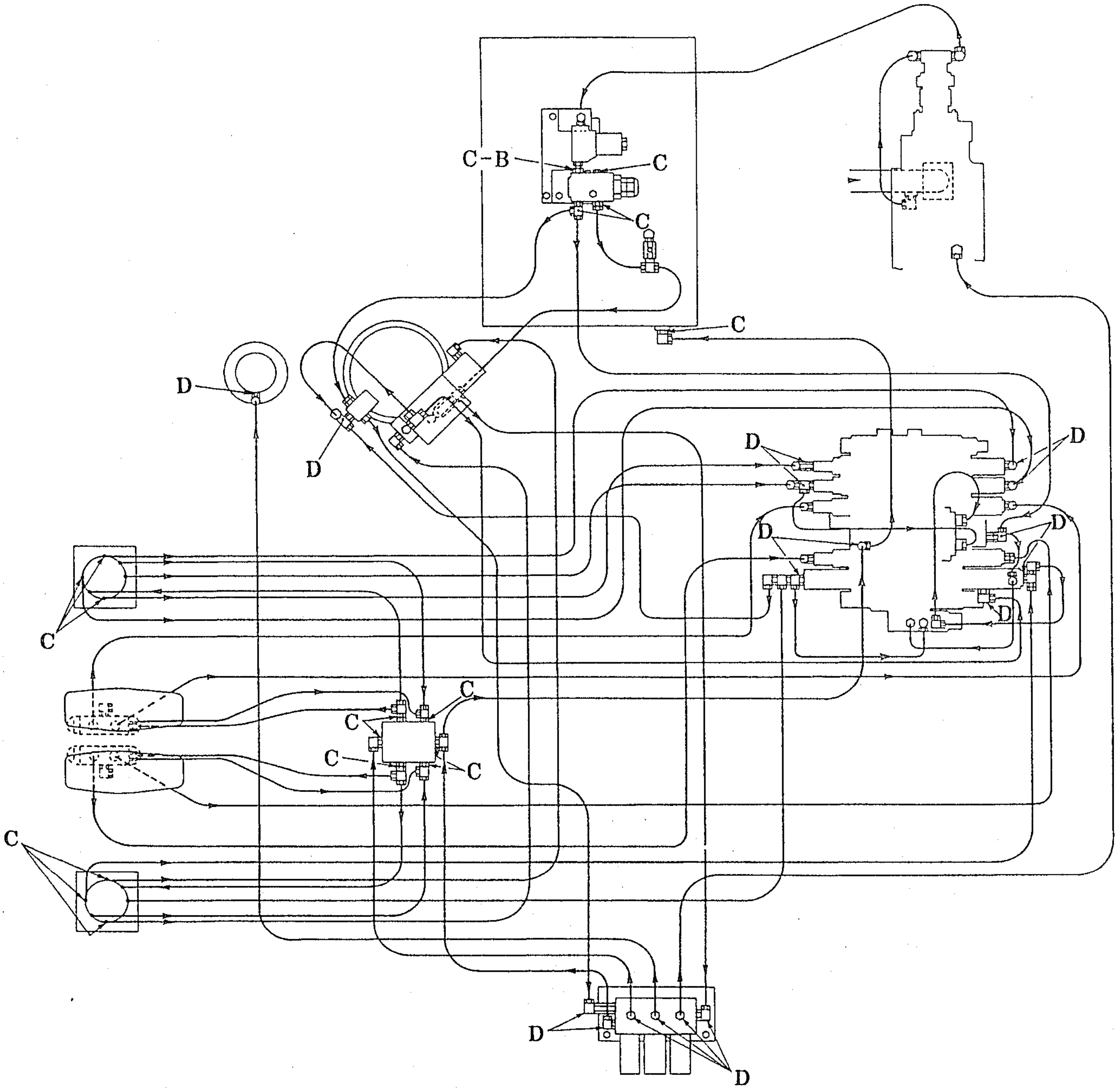

C–B
C
C
C
D
D
D
D
D
D
C
C
C
C
C
C
D
D

Fig. 12B

Fig. 12B

Table 5 Unit: kgf·m (ft·lbs)

Symbol	Size	O ring port tightening torque
B	PF 1/2	10.0~12.0 (72~86)
C	PF 3/8	7.0~ 8.0 (50~57)
D	PF 1/4	3.5~3.9 (25~28)

BooK code No. S5LE2305E

KOBELCO

SHOP MANUAL SK60

UPPER FRAME

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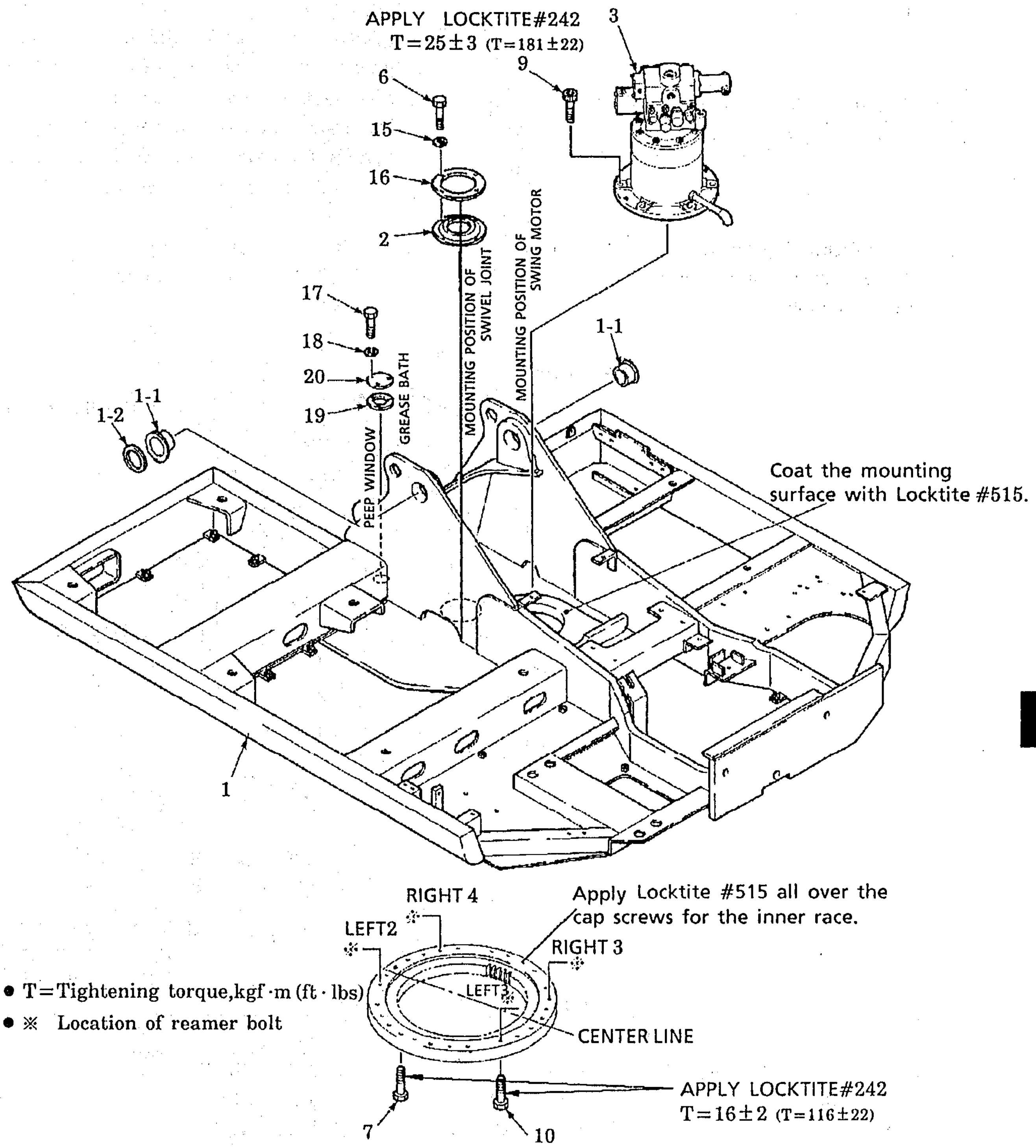
KOBE STEEL, LTD.

Applicable Machines
LE-11001~

Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE2305E K

1. CONSTRUCTION OF UPPER FRAME


APPLY LOCKTITE#242
T=25±3 (T=181±22)
3
9
6
15
16
2
17
18
20
19
1-1
1-2
1-1
GREASE BATH
PEEP WINDOW
MOUNTING POSITION OF SWIVEL JOINT
MOUNTING POSITION OF SWING MOTOR
Coat the mounting surface with Locktite #515.
1
RIGHT 4
LEFT2 ※
※
Apply Locktite #515 all over the cap screws for the inner race.
RIGHT 3
※
LEFT3 ※
CENTER LINE
APPLY LOCKTITE#242
T=16±2 (T=116±22)
7
10

☞ ● T=Tightening torque,kgf·m (ft·lbs)

● ※ Location of reamer bolt

Fig. 1 Upper frame

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
1	UPPER FRAME	1	6	CAPSCREW	4	16	COVER	1
1-1	BUSHING	2	7	CAPSCREW	19	17	CAPSCREW	3
1-2	COVER	1	9	SOCKET BOLT	6	18	WASHER	3
2	DUST COVER	1	10	REAMER BOLT	4	19	RUBBER PACKING	1
3	SWING MOTOR ASSY	1	15	WASHER	4	20	COVER	1

2. HYDRAULIC OIL TANK

2.1 CONSTRUCTION

Specifications	
Capacity	75ℓ (19.8 gal) (Level)
Weight	115kg (254 lbs) (Dry)

☞ ● T=Tightening torque, kgf · m (ft·lbs)
● The tank is integral with the fuel tank.

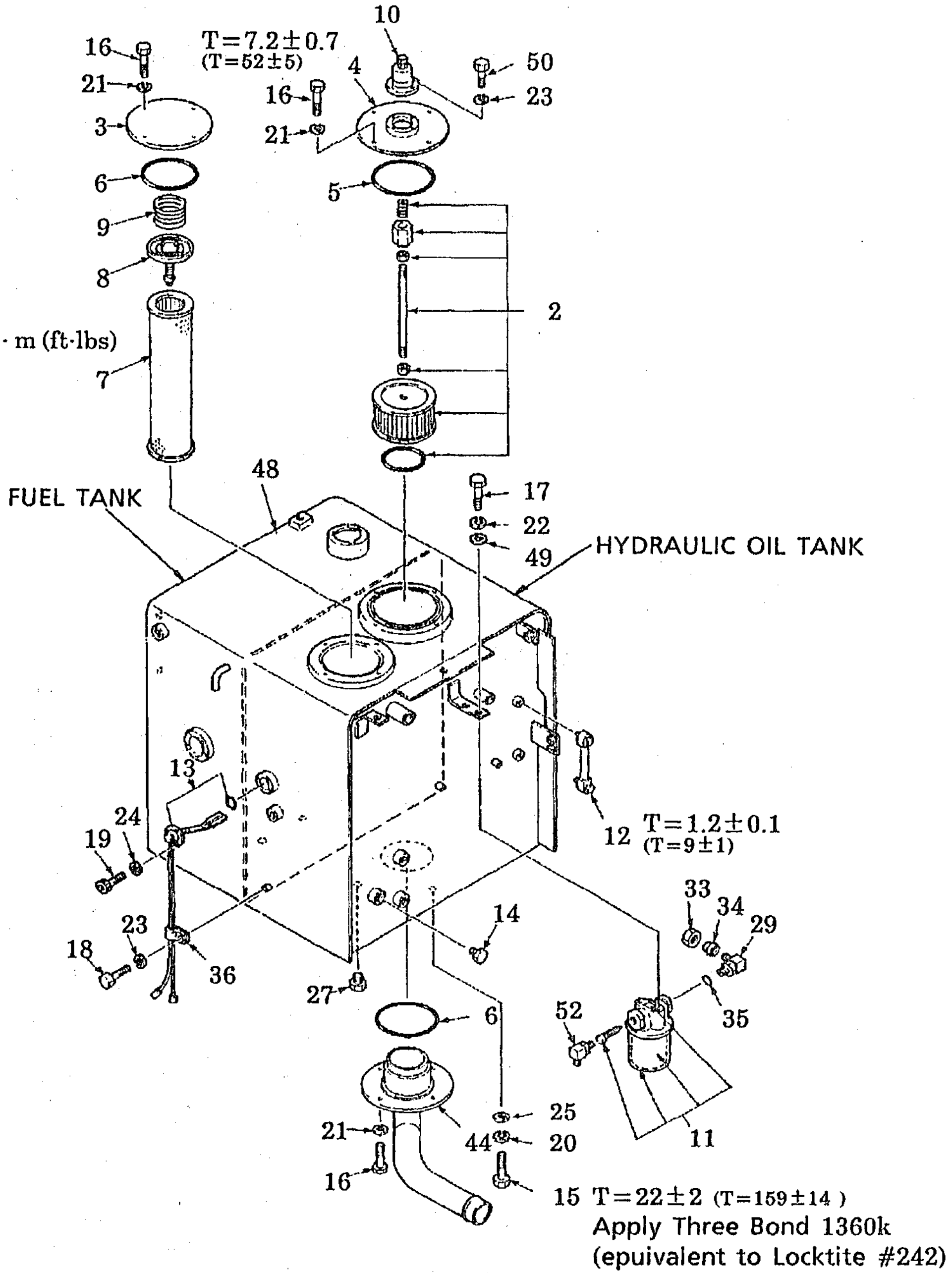

10
16
21
3
T=7.2±0.7
(T=52±5)
4
16
21
50
23
6
5
9
8
2
7
48
FUEL TANK
17
22
49
HYDRAULIC OIL TANK
13
24
19
12 T=1.2±0.1
(T=9±1)
33
34
29
14
23
18
36
27
6
52
35
25
21
44
20
11
16
15 T=22±2 (T=159±14)
Apply Three Bond 1360k
(epuivalent to Locktite #242)

Fig. 2 Hydraulic oil tank

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
2	SUCTION STRAINER	1	14	PLUG	1	27	PLUG	1
3	FLANGE	1	15	CAPSCREW	3	29	ELBOW	1
4	FLANGE	1	16	CAPSCREW	12	33	NUT	1
5	O RING	1	17	CAPSCREW	2	34	SLEEVE	1
6	O RING	1	18	CAPSCREW	1	35	O RING	1
7	RETURN FILTER	1	19	CAPSCREW	3	36	CLIP	1
8	BYPASS VALVE	1	20	LOCK WASHER	3	44	PIPE	1
9	SPRING	1	21	LOCK WASHER	12	48	HYDRAULIC OIL TANK (INCL. FUEL TANK)	1
10	BREATHER	1	22	LOCK WASHER	2			
11	DRAIN FILTER	1	23	LOCK WASHER	5	49	WASHER	2
12	LEVEL GAUGE	1	24	LOCK WASHER	3	50	CAPSCREW	4
13	LEVEL SWITCH	1	25	WASHER	3	52	ELBOW	1

2.2 Removal and Installation of hydraulic Oil Tank

2.2.1 Removal

1) Drive the machine to level ground, turn the upper frame to a 90° angle to the lower frame, and stop the engine (see Fig. 3).
2) Clean the area around the hydraulic oil tank.
3) Loosen the breather nut and press the center of the breather to remove any compressed air from the hydraulic oil tank.
4) Remove the guards and brackets around the hydraulic oil tank.
5) Disconnect the suction hose, harnesses, drain filter, other hoses, etc.
6) Remove the drain plug (27) and drain out all the hydraulic oil.
7) Remove the mounting cap screws (15).
8) Attach a lifting device to the tank, and lift out the tank.

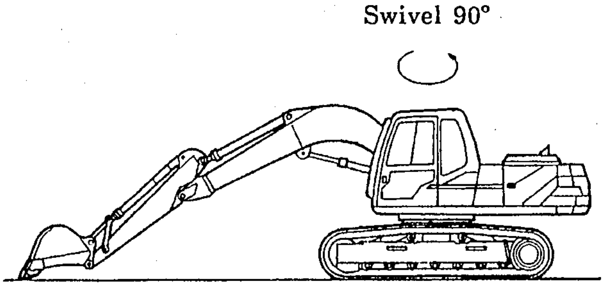


Fig. 3 Position in which to stop the engine

☞ Drain out both the hydraulic oil and fuel (130liters (34.3 gal) when filled up).

2.2.2 Installation

1) Attach a lifting device to the tank, and lower the tank to the mounting position.
2) Tighten mounting the cap screws (15) to the specified torque of 22±2 kgf·m (159±14 ft·lbs).
3) Install the suction hose, drain filter, and harnesses back in their original positions.
4) Install the brackets and guards.
5) Remove the flange (4) and add designated hydraulic oil.
6) Check the oil level with the level gauge.
7) Install the flange, start the engine, and remove any air from the hydraulic circuit by running the engine at low idle for 2 to 3 minutes.
8) Recheck the hydraulic oil level with the machine in the position shown in Fig. 3.

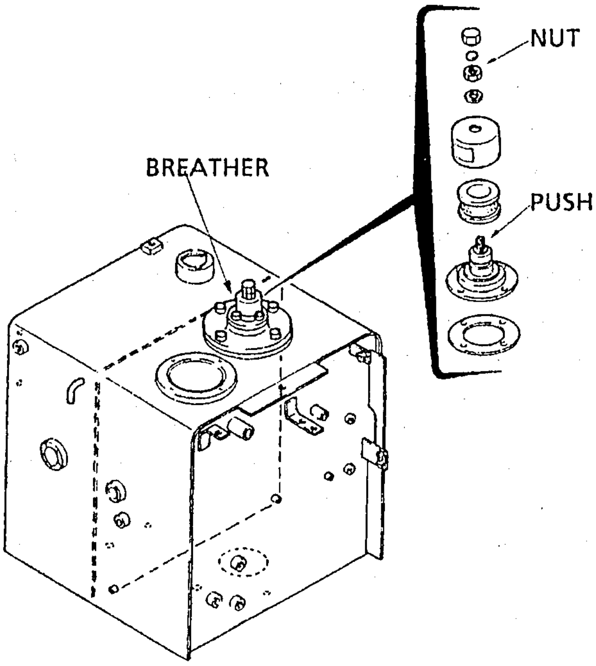


Fig. 4 Hydraulic oil tank

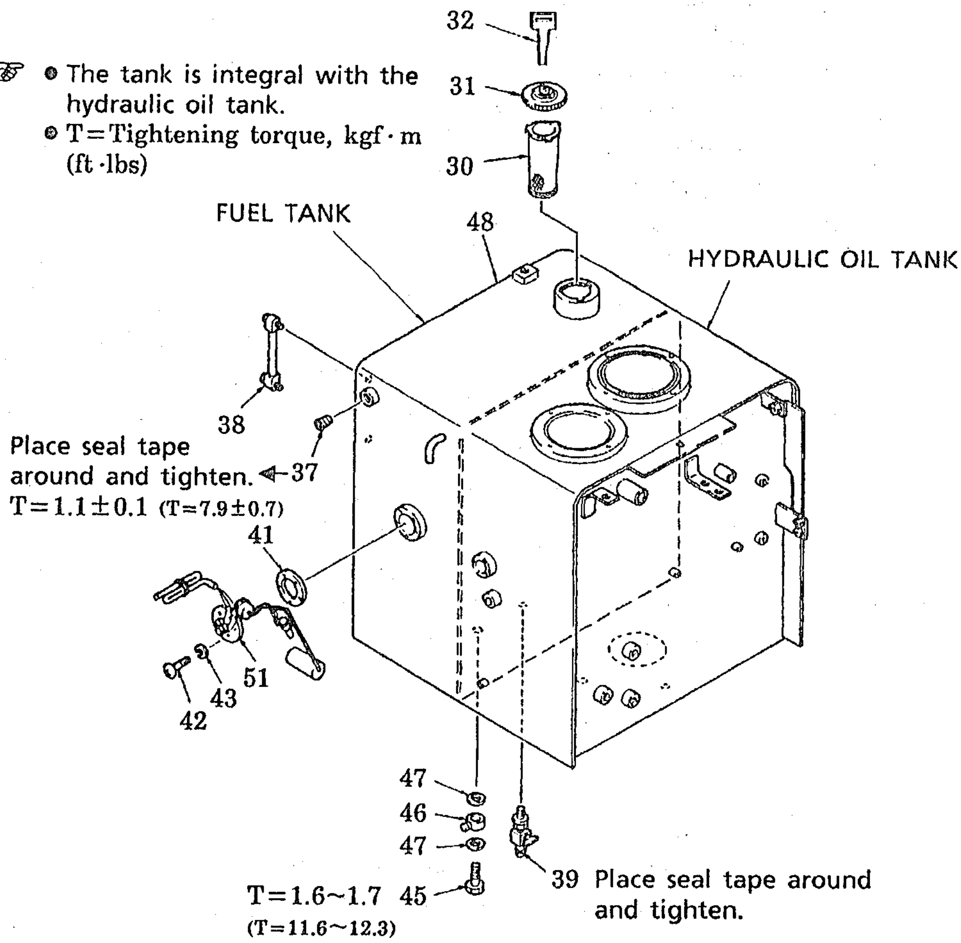
3. FUEL TANK

3.1 CONSTRUCTION

No.	NAME	Q'ty
30	STRAINER	1
31	FILTER CAP	1
32	KEY	1
37	PLUG	1
38	LEVEL GAUGE	1
39	DRAIN COCK	1
41	PACKING	1
42	MACHINE SCREW	5
43	LOCK WASHER	5
45	BOLT	1
46	JOINT	1
47	GASKET	2
48	FUEL TANK (INCL. HYDRAULIC OIL TANK)	1
51	SENDING UNIT	1

Specifications

Capacity	130ℓ (34.3gal) (Full)
Weight	115kg (254 lbs) (Dry)



☞ ◎ The tank is integral with the hydraulic oil tank.
◎ T=Tightening torque, kgf·m (ft·lbs)

Place seal tape around and tighten. ←37
T=1.1±0.1 (T=7.9±0.7)

T=1.6~1.7 (T=11.6~12.3)

39 Place seal tape around and tighten.

Fig. 5 Fuel tank

3.2 Removal and Installation of Fuel Tank

3.2.1 Removal

1) Turn the upper frame to a 90° angle to the lower frame, and stop the engine.
2) Remove the handrail from the tank top.
3) Disconnect the fuel hoses, and the cable coupler of the sending unit (51).
4) Clean the tank top, and then loosen the filler cap (31) with the key (32).
5) Place a clean container under the tank to receive the remaining fuel, and then remove the drain cock (39) to drain the fuel.
6) Remove the mounting cap screws (12), and lift out the tank with a wire rope, using the hook and handrail mounting seat.

3.2.2 Installation

1) Lift the tank with a wire rope, and lower it to the mounting position. Tighten the mounting screws to the specified torque.
2) Connect the fuel hoses, and connect the cable coupler of the sending unit (51).
3) Tighten the drain cock (39), and refill with fuel using a pump or the like.
4) Install the handrail.

⚠ Pay particular attention to flames, dust, and sand when handling fuel, which is a hazardous substance.

☞ ◎For how to purge air from the fuel line, refer to a separate instruction manual.
◎Confirm that there are no leaks.

4. REMOVAL AND INSTALLATION OF COUNTERWEIGHT

4.1 REMOVING COUNTERWEIGHT (see Fig. 8)

⚠ The counterweight weighs about 750kg (1700 lbs). Take due care in performing crane work. To lift the counterweight horizontally, get ready a wire rope and a chain block, each about 1,500mm (59.0in) long, as shown in Fig. 6.

1) Disconnect the cable couplers of the swing flasher and the rear working light.
2) Dismantle parts (32, 33, 37) mounted to the engine cover, release the engine cover with key (30) and lift it up.
3) Remove the sems bolt (21) plug (24) holding the safety bumpers (9,16) and brackets (8, 18).
4) Remove the two plugs (23) from the top of the counterweight, and screw in eye-bolts (M24), and attach a wire rope and chain block with no slack.
5) Remove cap screw (2) (3), using a box end wrench (M24) and a long pipe for leverage, or a power wrench.
6) Lift the counterweight just a little, and after confirming safety all around, lift it up and out.

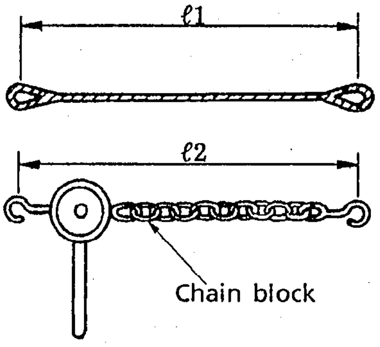


Fig. 6 Lifting devices

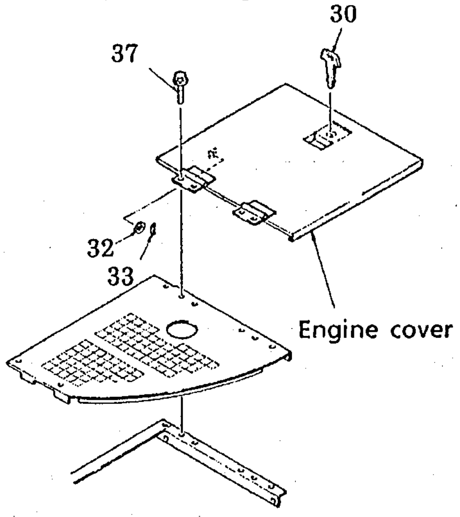


Fig. 7 Removing the engine cover

4.2 INSTALLING COUNTERWEIGHT

⚠ Lift the counterweight just a little, and after confirming safety all around, proceed to install it.

1) Lower the counterweight to the mounting face at the rear of the upper frame.
2) Connect the cable couplers of the swing flasher and the rear working light.
3) Install the engine cover, protector and bracket at their specified positions.

☞ •Adjust the clearance between the counterweight and the guards to 10±3mm (0.39"±0.12"), and make it level to within 6mm (0.2in).
•T=Tightening torque, kgf·m (ft·lbs)

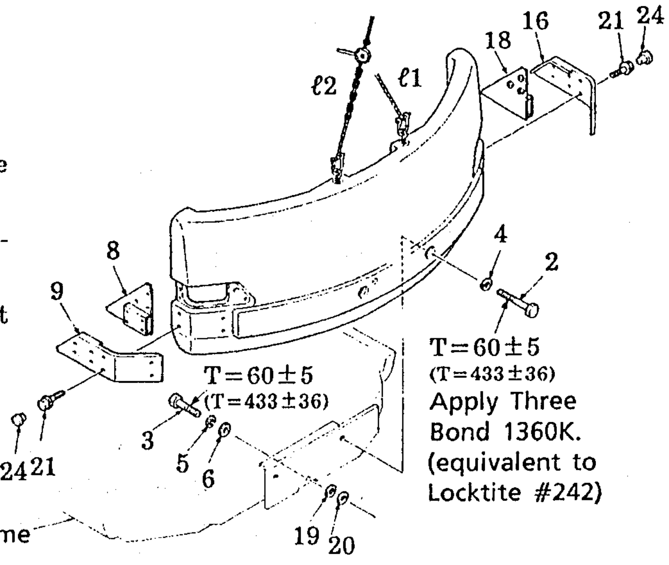


Fig. 8 Removing the counterweight

5. REMOVAL AND INSTALLATION OF CAB

5.1 REMOVING CAB (see Fig. 9)

1) Attach wire ropes to the lifting hooks on top of the cab, and lift the cab until there is no slack in the wire ropes.
2) Remove a total of 9 mounting cap screws (3, 4), and 2 cap screws (23) located at the rear of the cab.
3) Disconnect the cable couplers of the windshield wipers, room lamp. radio, and antenna.
4) Lift the cab just a little, and after confirming safety all around, lift it up and out.
(Cab weight=about 260kg (573 lbs))

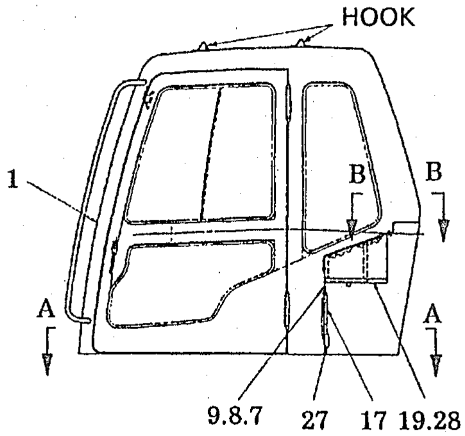
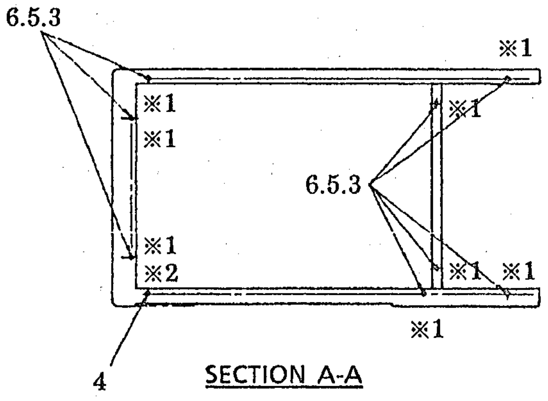


Fig. 9 Cab

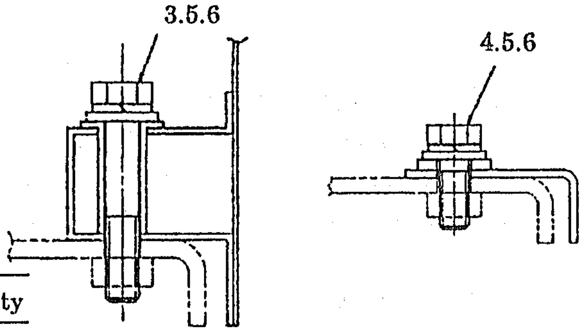
5.2 INSTALLING CAB (see Fig. 10)

1) Attach wire ropes to the lifting hooks on top of the cab, and lower the cab to the mounting position.
2) Tighten the 11 mounting cap screws (3, 4, 23).
3) Connect the cable couplers of the windshield wipers, room lamp, radio and antenna.

☞ Take care that the cab frame does not hit the control board when remo-ving or installing the cab using a crane.

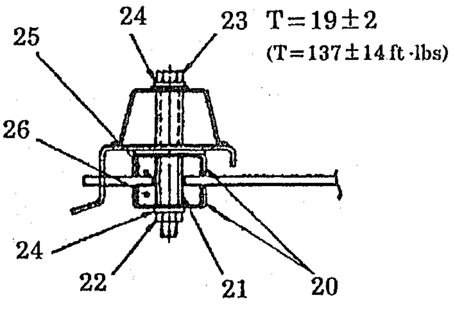


SECTION A-A



Mounting detail (※1) Mounting detail (※2)

No.	NAME	Q'ty	No.	NAME	Q'ty
1	CAB ASSY	1	20	COVER	4
3	CAPSCREW	8	21	SPACER	2
4	SEMS-BOLT	1	22	U-NUT	2
5	LOCK WASHER	8	23	CAPSCREW	2
6	WASHER	8	24	WASHER	4
7	CAPSCREW	6	25	RUBBER RING	2
8	LOCK WASHER	12	26	CUSHION RUBBER	4
9	WASHER	12	27	INSULATION SOUND	1
17	COVER ASSY	1	28	CAPSCREW	6
19	BOX ASSY	1			



SECTION B-B

Fig. 10 Installing cab

6. REMOVAL AND INSTALLATION OF UPPER FRAME

6.1 DISMANTLING UPPER FRAME (FULLY EQUIPPED)

⚠ The upper frame weights about 2.0tons (4400 lbs). Pay due attention to safe footing for crane work and the area around the crane before proceeding to remove or install the upper frame.

1) Remove the working attachment (see the Attachment manual).
2) Disconnect the 4 hydraulic oil hoses, 1 drain hose, and one pilot oil hose. (Fig. 11)

☞ •Bundle the hoses.
•Blind plug each disconnected hose and tube.

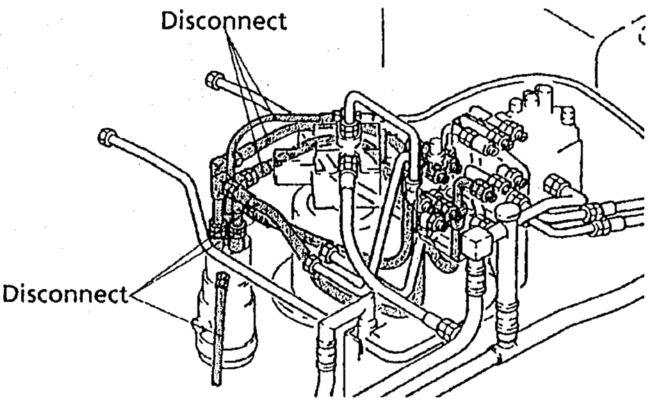


Fig. 11 Hydraulic oil and pilot oil pipes and hoses

3) Remove the cap screws (A) fixing the outer race of the slewing ring.

☞ Cap screw : 24mm (0.94in) in width across flats.

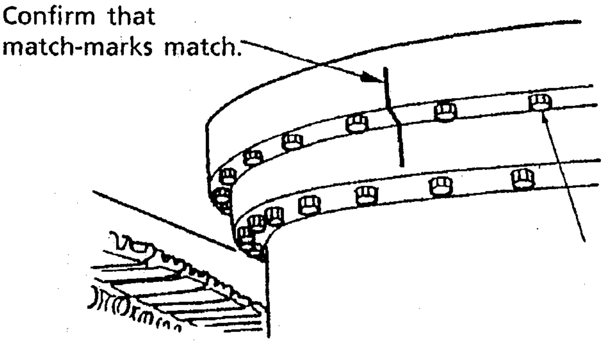


Fig. 12 Slewing ring installed

4) Remove the cab, counterweight and guard, place a wire sling around the upper frame and lift it by crane so the wire sling is not slack. (see Fig. 13).
5) Lift the upper frame just alittle, and after confirming safety all around, lift it up and out.

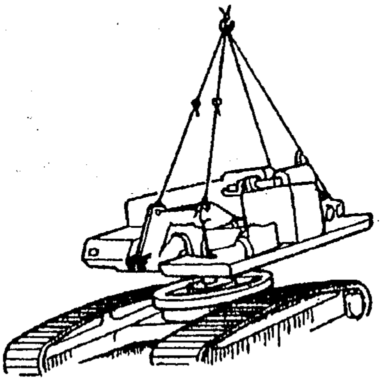


Fig. 13 Lifting the upper frame

6.2 MOUNTING UPPER FRAME (FULLY EQUIPPED)

1) Bundle the hoses attached to the swivel joint and place them upright.
2) Apply Threebond 1215 (Locktite #515) to all the side face in the capscrews of the slewing ring.

⚠ Lower the upper frame so that the swing pinion and the slewing ring are engaged.

☞ •For tightening torque, refer to Fig. 1.
•Tighten diagonally opposite screws in sequence.

3) Connect the hoses disconnected for removal.

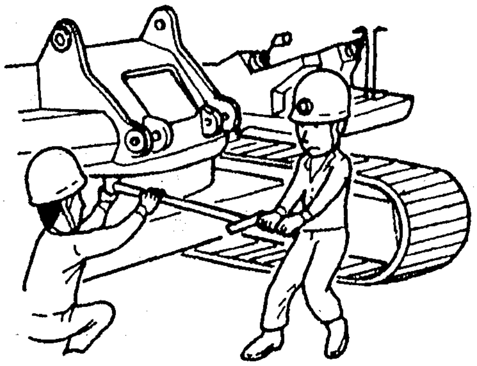
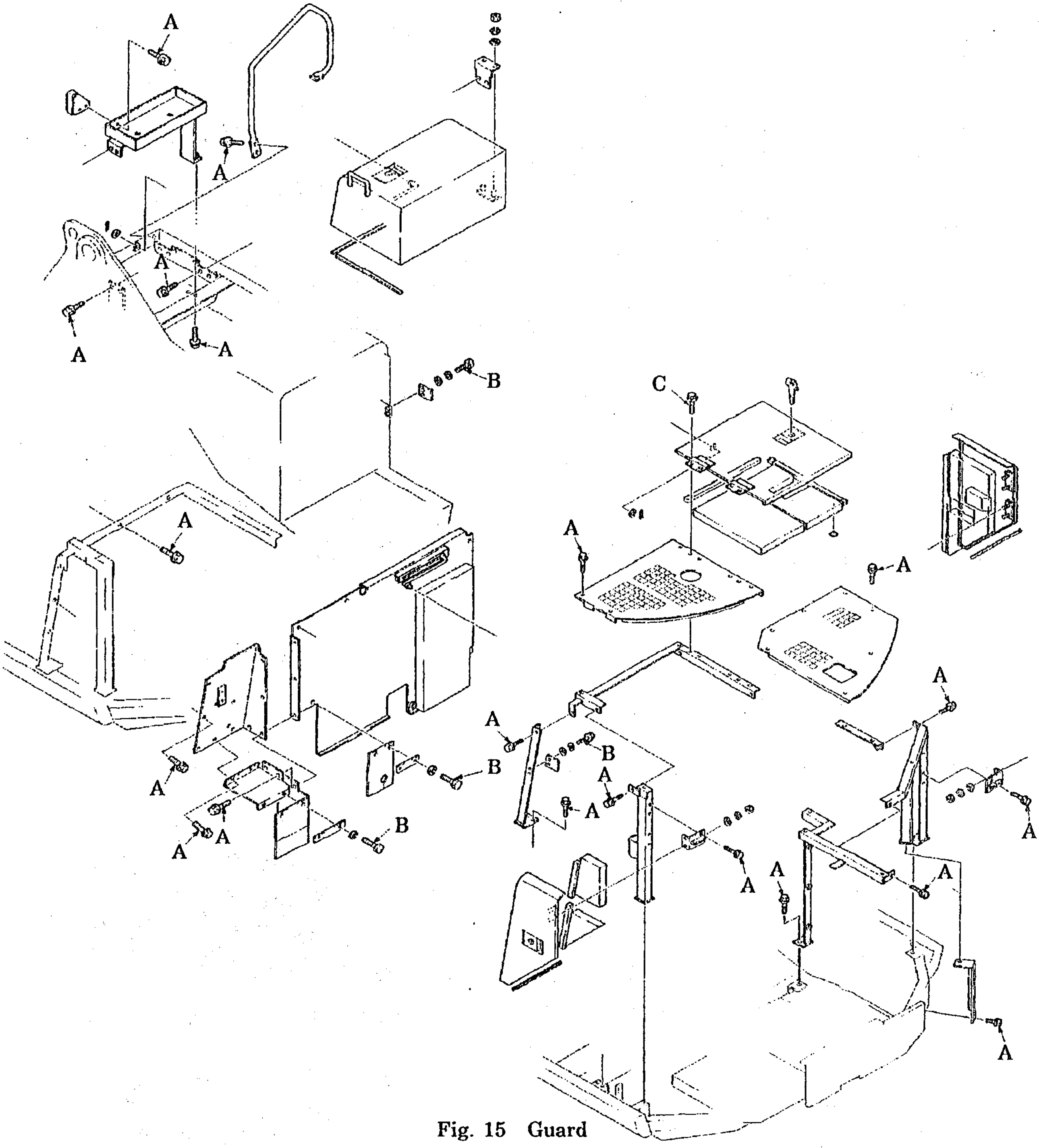


Fig. 14 Installing the upper frame

7. MAINTENANCE STANDARDS

7.1 GUARD



A
A
A
A
A
B
C
A
A
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A
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B
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B
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A
A
A
A
A

Fig. 15 Guard

Table 1

Unit : kgf·m (ft·lbs)

Symbol	Item		Standard Value	Remedy
A	Sems-bolt	(M12)	8.5±0.5 (61.4±3.6)	Retighten.
B	Capscrew	(M8)	3.6±0.4 (26.0±2.9)	
C	Sems-bolt	(M10)	5.3±0.3 (38.3±2.2)	

7.2 UPPER HYDRAULIC PIPING

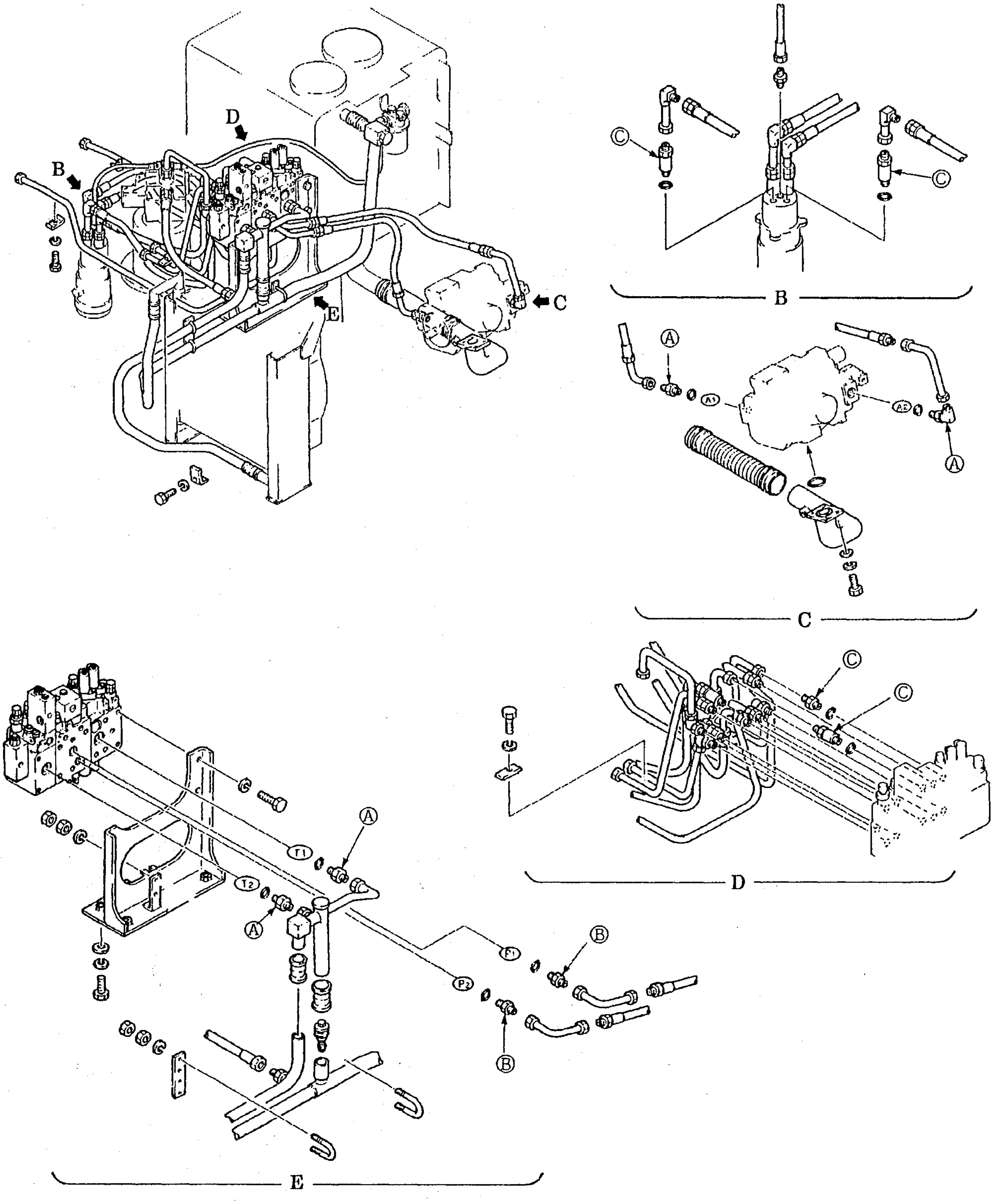

D
B
E
C
©
©
B
Ⓐ
A1
A2
Ⓐ
C
©
©
D
Ⓐ
T1
T2
Ⓐ
P1
P2
Ⓑ
Ⓑ
E

Fig. 16 Upper hydraulic piping

Table 2 Unit: kgf·m (ft·lbs)

Symbol	Item	Standard Value	Remedy
Ⓐ	Connector (PF3/4-Ø22)	22±2 (159±14)	
Ⓑ	Connector (PF1/2-Ø22)	11±1 (79±7)	Retighten
©	Connector (PF1/2-Ø18)	11±1 (79±7)	

7.3 UNDER COVER

Table 3 Unit: kgf · m (ft · lbs)

Symbol	Item	Q'ty	Standard Value	Remedy
A	Sems-bolt M12	22	8.5±0.5 (61±4)	Retighten.

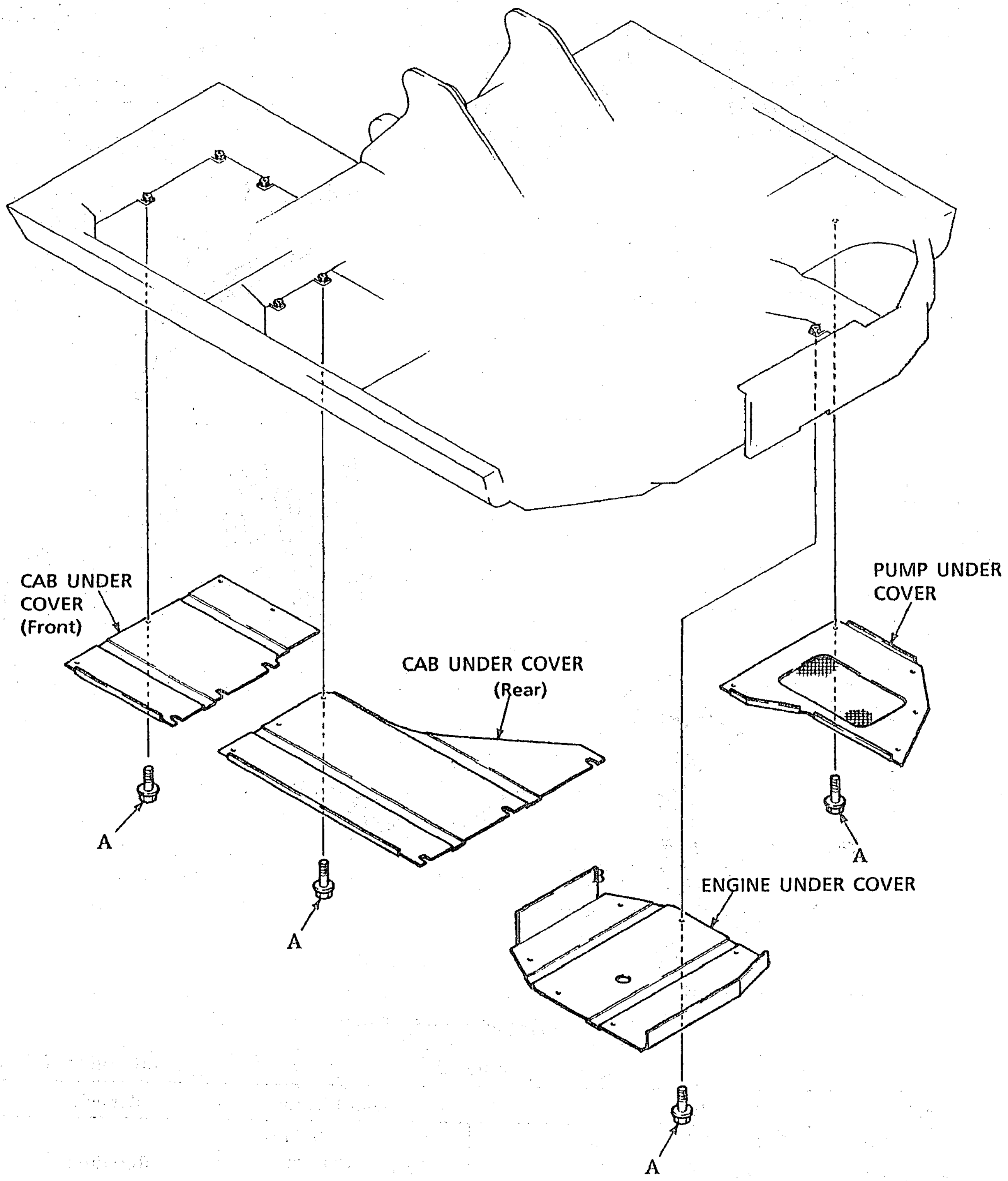

CAB UNDER COVER (Front)
CAB UNDER COVER (Rear)
PUMP UNDER COVER
ENGINE UNDER COVER
A
A
A
A

Fig. 17

Book code No. S5LE2505E

KOBELCO

SHOP MANUAL SK60

ELECTRICAL SYSTEM

TABLE OF CONTENTS

1. LOCATION OF ELECTRICAL COMPONENTS

1.1 Control Board 1
2. ELECTRICAL CIRCUIT DIAGRAMS 3

3. WIRING HARNESSES

3.1 Location of Wiring Harnesses 5
3.2 Details of Wiring Harnesses 7

KOBE STEEL, LTD.

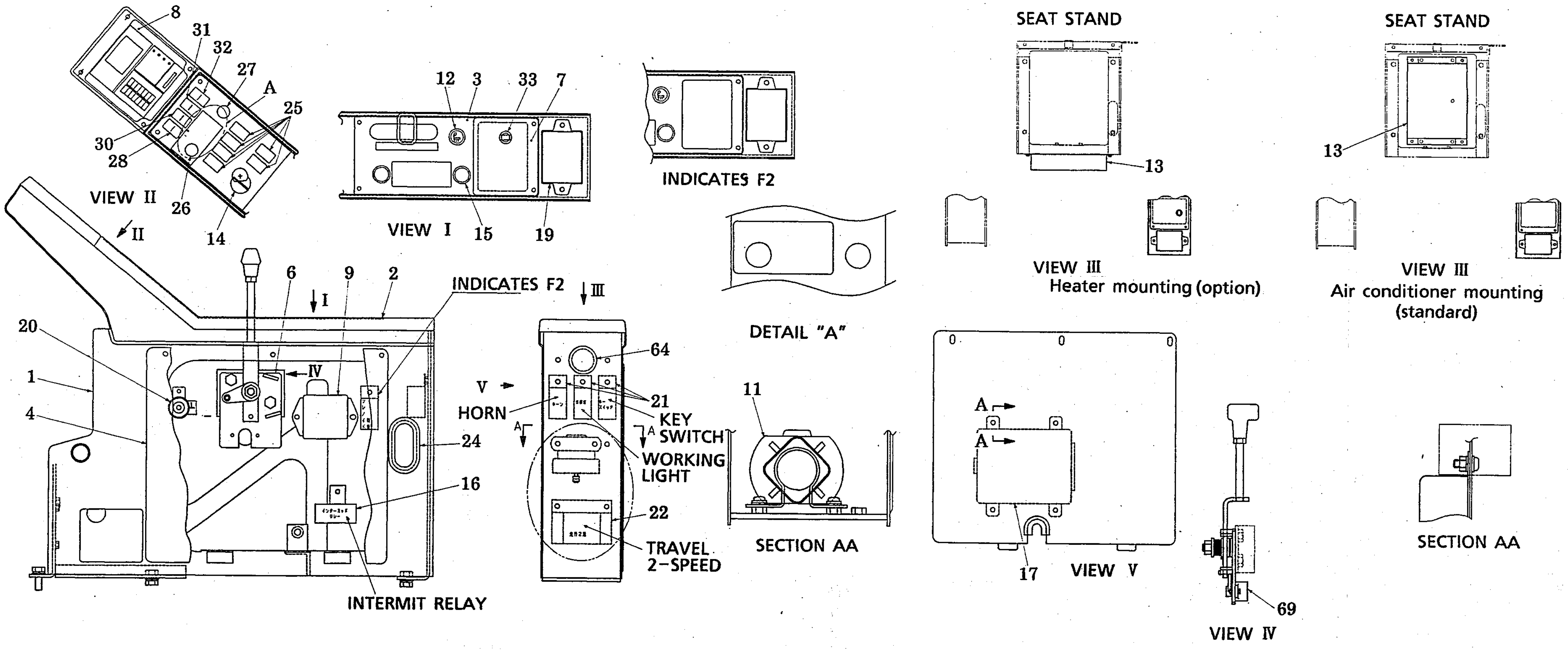
Applicable Machines
LE-11001~

		NORTH AMERICA			NORTHEN EUROPA			EUROPA					CUSTOMER'S COUNTRY							
	PAGE	KAI			FINLAND	NORWAY	SWEDEN	DENMARK	ENGLAND	HOLLAND BELGIUM PORTUGAL	AUSTRIA	SWISS	CENTRAL SOUTH AMERICA	NEW ZEALAND	AUSTRALIA	TAIWAN	CHINA	NEAR MIDDLE AFRICA		
SELECT PAGE	1,2	B			B	B	B	B	B	B	B	B	A	A	A	A	A	A		
	7,8	B			C	C	C	B	B	B	B	B	A	A	A	A	A	A		

Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE2505E K

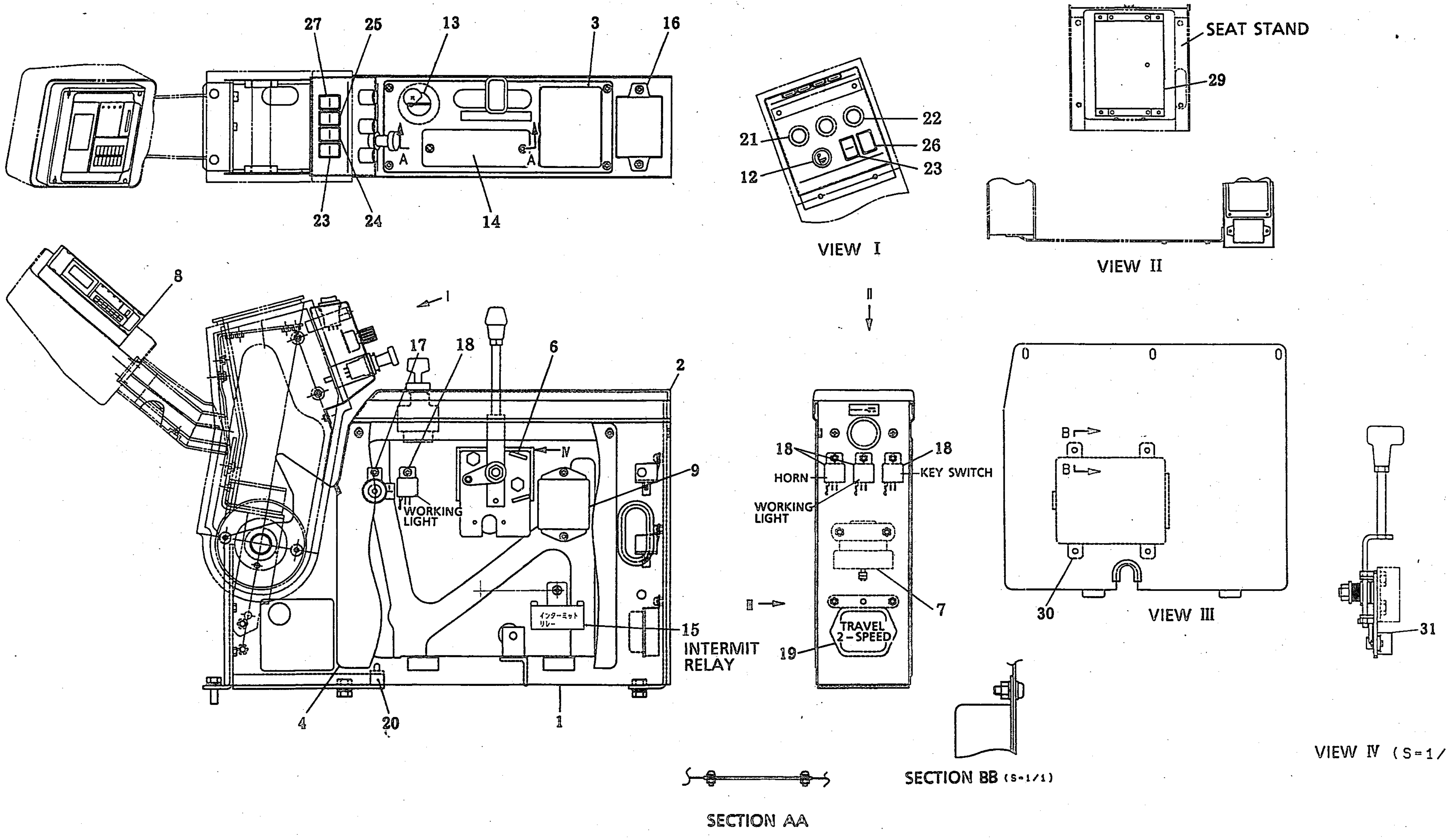
1. LOCATION OF ELECTRICAL COMPONENTS

1.1 CONTROL BOARD


8
31
32
27
A
25
30
28
26
14
VIEW II
II
12
3
33
7
VIEW I
15
19
INDICATES F2
DETAIL "A"
SEAT STAND
13
VIEW III
Heater mounting (option)
SEAT STAND
13
VIEW III
Air conditioner mounting
(standard)
6
9
2
I
INDICATES F2
III
20
1
4
IV
24
16
INTERMIT RELAY
64
V
HORN
21
KEY
SWITCH
WORKING
LIGHT
22
TRAVEL
2-SPEED
A
A
11
SECTION AA
A
A
17
VIEW V
69
VIEW IV
SECTION AA

No.	NAME	Q'ty	
		F1	F2
1	CONTROL STAND	1	1
2	INSTRUMENT PANEL	1	1
3	INSTRUMENT PANEL	1	1
4	COVER	1	1
6	THROTTLE LEVER ASSY	1	1
7	COVER	1	–
8	CLUSTER GAUGE	1	1
9	FLASHER UNIT	1	1
11	STARTER SAFETY RELAY	1	1
12	CIGARETTE LIGHTER	1	1
13	CONTROLLER : KPSS	1	1
14	STARTER SWITCH	1	1
15	TUNER	1	1
16	INTERMIT RELAY	1	1
17	CONTROLLER : CLUSTER GAUGE	1	1
19	FUSE BOX	1	1
20	BUZZER	1	1
21	RELAY	3	4
22	RELAY ASSY	1	1
24	GROMMET	1	1
25	CAP	6	6
26	SWITCH : MODE CHANGEOVER	1	1
27	SWITCH : WIPER	1	1
28	SWITCH : WORKING LIGHT/ WORKING TALL LIGHT	1	1
30	SWITCH : SWING FLASHER	1	1
31	SWITCH : AUTO ACCELE	1	1
32	SWITCH : BUZZER STOP	1	1
33	SWITCH : HEATER	1	–
63	DIODE	2	2
64	GROMMET	1	1
69	POTENTION METER	1	1

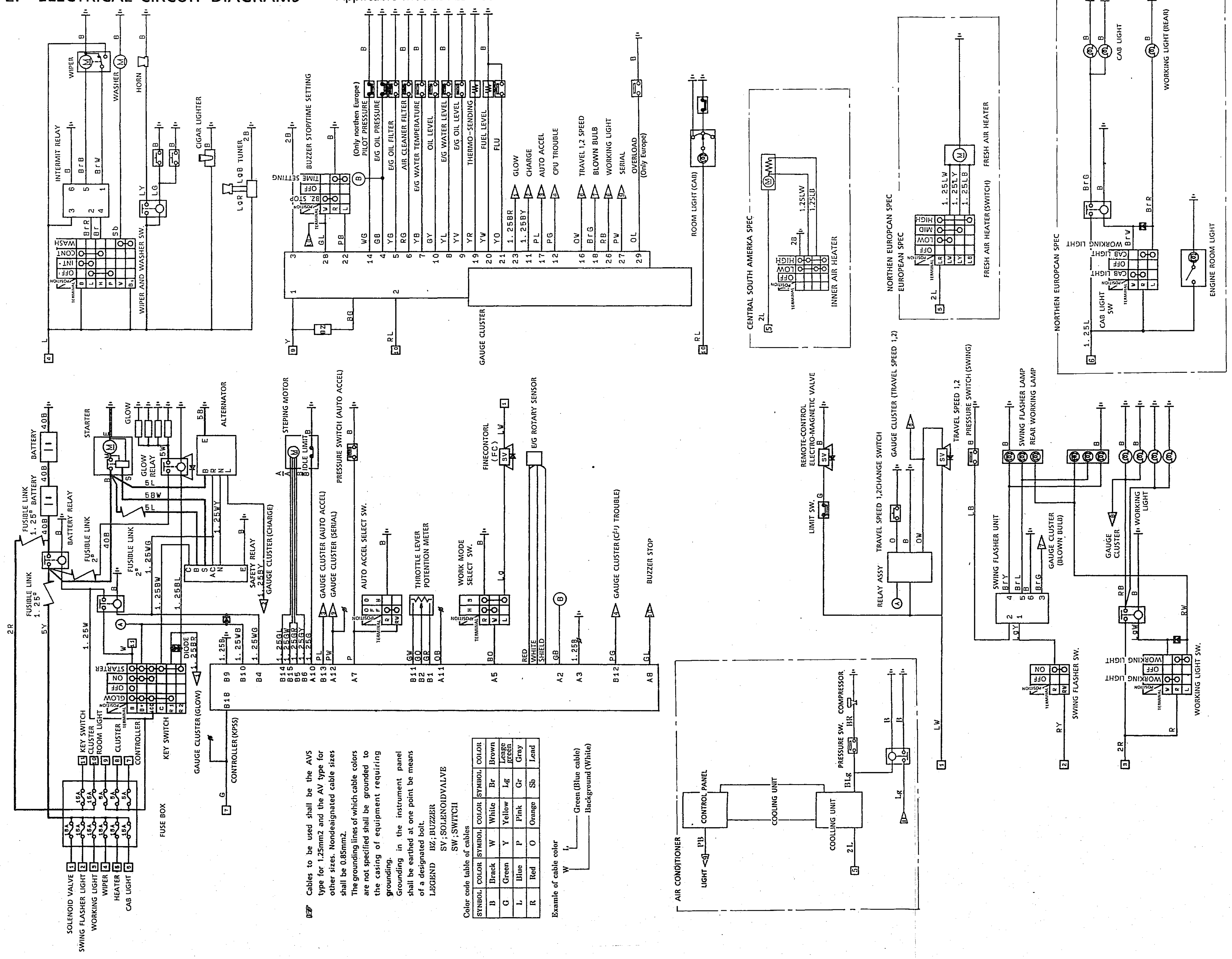
F1 : Optional specification
F2 : Standard specification


27
25
13
3
16
23
24
14
A
A
21
22
26
12
23
VIEW I
SEAT STAND
29
VIEW II
8
I
17
18
6
2
IV
9
WORKING LIGHT
15
INTERMIT RELAY
インターミットリレー
4
20
1
II
18
18
HORN
WORKING LIGHT
KEY SWITCH
7
TRAVEL 2-SPEED
19
II
B
B
30
VIEW III
31
SECTION AA
SECTION BB (S=1/1)
VIEW IV (S=1/2)

No.	NAME	NORTHEN EUROPA Q' ty	EUROPA Q' ty
1	CONTROL STAND	1	1
2	INSTRUMENT PANEL	1	1
3	INSTRUMENT PANEL	1	1
4	COVER	1	1
6	THROTTLE LEVER ASSY	1	1
7	STARTER SAFETY RELAY	1	1
8	CLUSTER GAUGE	1	1
9	FLASHER UNIT	1	1
12	CIGARETTE LIGHTER	1	1
13	STARTER SWITCH	1	1
14	TUNER	–	1
15	INTERMIT RELAY	1	1
16	FUSE-BOX	1	1
17	BUZZER	1	1
18	RELAY	4	3
19	RELAY ASSY : TRAVEL-2 SPEED	1	1
20	RESISTOR	1	1
21	SWITCH : MODE WORKING	1	1
22	SWITCH : WIPER	1	1
23	SWITCH : WORKING LIGHT/ WORKING TALL LIGHT	1	–
24	SWITCH : SWING FLASHER	1	1
25	SWITCH : AUTO ACCELE	1	1
26	CAP	1	2
27	SWITCH : BUZZER STOP/ TIME ADJUSTMENT	1	1
29	CONTROLLER : KPSS	1	1
30	CONTROLLER : CLUSTER GAUGE	1	1
31	POTENTION METER	1	1

2. ELECTRICAL CIRCUIT DIAGRAMS

Applicable Models : LE11001~


INTERMIT RELAY
WIPER
WASHER
HORN
WIPER AND WASHER SW.
CIGAR LIGHTER
LoB TUNER
BUZZER STOP/TIME SETTING
(Only northen Europe) PILOT PRESSURE
E/G OIL PRESSURE
E/G OIL FILTER
AIR CLEANER FILTER
E/G WATER TEMPERATURE
OIL LEVEL
E/G WATER LEVEL
E/G OIL LEVEL
THERMO-SENDING
FUEL LEVEL
FLU
GLOW
CHARGE
AUTO ACCEL
CPU TROUBLE
TRAVEL 1,2 SPEED
BLOWN BULB
WORKING LIGHT
SERIAL
OVERLOAD (Only Europe)
GAUGE CLUSTER
ROOM LIGHT (CAB)
CENTRAL SOUTH AMERKA SPEC
INNER AIR HEATER
NORTHEN EUROPCAN SPEC
EUROPEAN SPEC
FRESH AIR HEATER (SWITCH)
FRESH AIR HEATER
NORTHEN EUROPCAN SPEC
CAB LIGHT
WORKING LIGHT (REAR)
CAB LIGHT SW
ENGINE ROOM LIGHT
BATTERY
FUSIBLE LINK
BATTERY RELAY
STARTER
GLOW
GLOW RELAY
ALTERNATOR
SAFETY RELAY
GAUGE CLUSTER (CHARGE)
STEPING MOTOR
IDLE LIMIT
PRESSURE SWITCH (AUTO ACCEL)
GAUGE CLUSTER (AUTO ACCEL)
GAUGE CLUSTER (SERIAL)
AUTO ACCEL SELECT SW.
THROTTLE LEVER POTENTION METER
WORK MODE SELECT SW.
FINECONTORL (FC)
E/G ROTARY SENSOR
GAUGE CLUSTER (CPU TROUBLE)
BUZZER STOP
KEY SWITCH
DIODE
GAUGE CLUSTER (GLOW)
CONTROLLER (KPSS)
FUSE BOX
SOLENOID VALVE
SWING FLASHER LIGHT
WORKING LIGHT
WIPER
HEATER
CAB LIGHT
CLUSTER
ROOM LIGHT
CONTROLLER
REMOTE-CONTROL ELECTRO-MAGNETIC VALVE
LIMIT SW.
TRAVEL SPEED 1,2CHANGE SWITCH
GAUGE CLUSTER (TRAVEL SPEED 1,2)
TRAVEL SPEED 1,2
PRESSURE SWITCH (SWING)
RELAY ASSY
SWING FLASHER LAMP
REAR WORKING LAMP
SWING FLASHER UNIT
GAUGE CLUSTER (BLOWN BULB)
SWING FLASHER SW.
GAUGE CLUSTER
WORKING LIGHT
WORKING LIGHT SW.
AIR CONDITIONER
LIGHT
CONTROL PANEL
COOLING UNIT
COOLLING UNIT
PRESSURE SW.
COMPRESSOR

Cables to be used shall be the AVS type for 1.25mm2 and the AV type for other sizes. Nondeaignated cable sizes shall be 0.85mm2.
The grounding lines of which cable colors are not specified shall be grounded to the casing of equipment requiring grounding.
Grounding in the instrument panel shall be earthed at one point be means of a designated bolt.

LEGEND BZ ; BUZZER
SV ; SOLENOIDVALVE
SW ; SWITCH

Color code table of cables

SYNBOL	COLOR	SYMBOL	COLOR	SYMBOL	COLOR
B	Brack	W	White	Br	Brown
G	Green	Y	Yellow	Lg	Leage green
L	Blue	P	Pink	Gr	Gray
R	Red	O	Orange	Sb	Lead

Examle of cable color

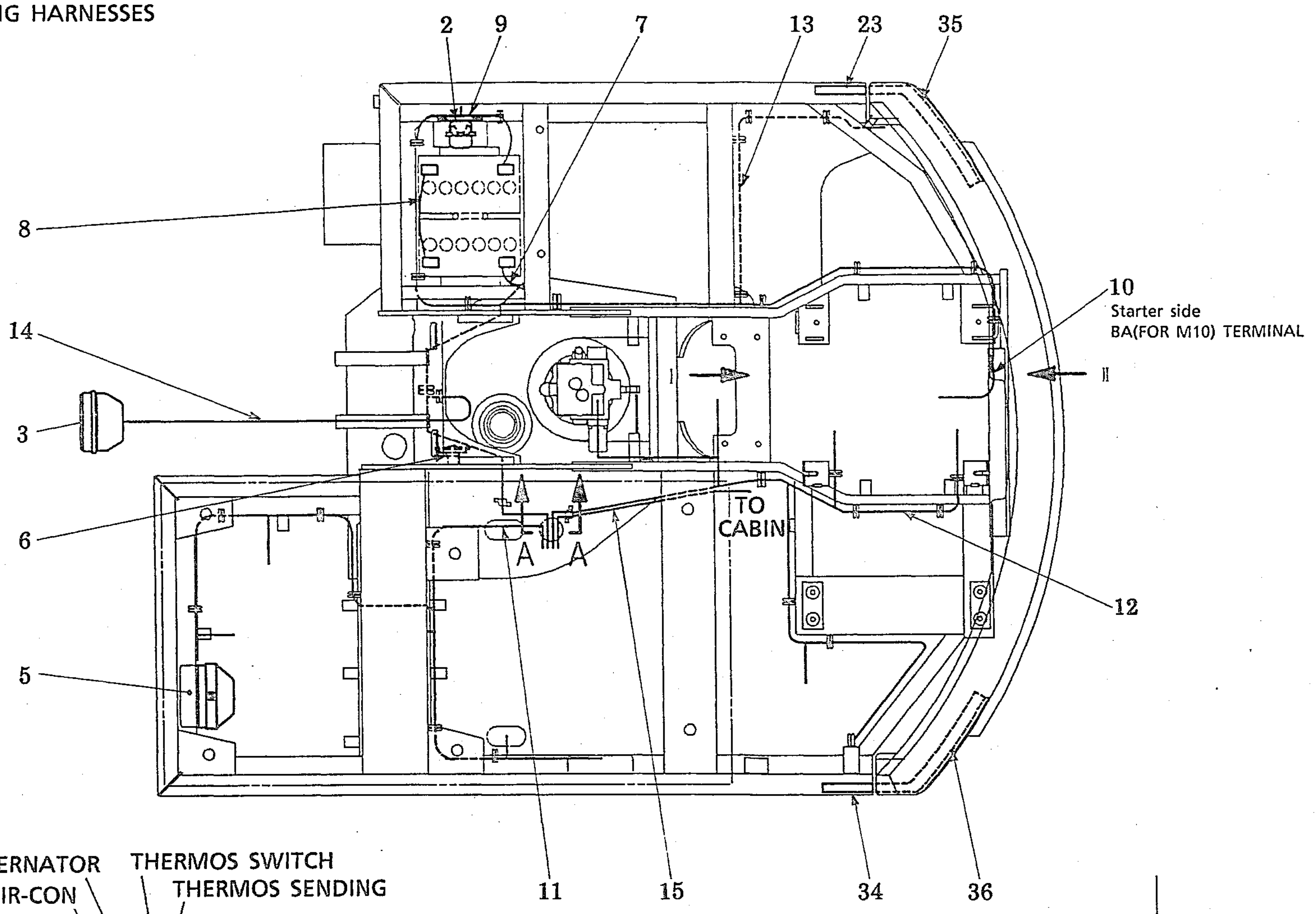
W L

Green (Blue cable)

Background (White)

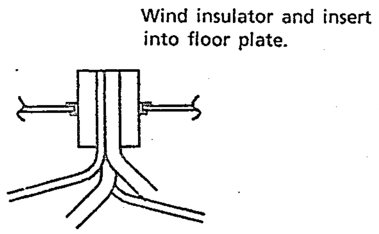
3. WIRING HARNESSES

3.1 LOCATION OF WIRING HARNESSES

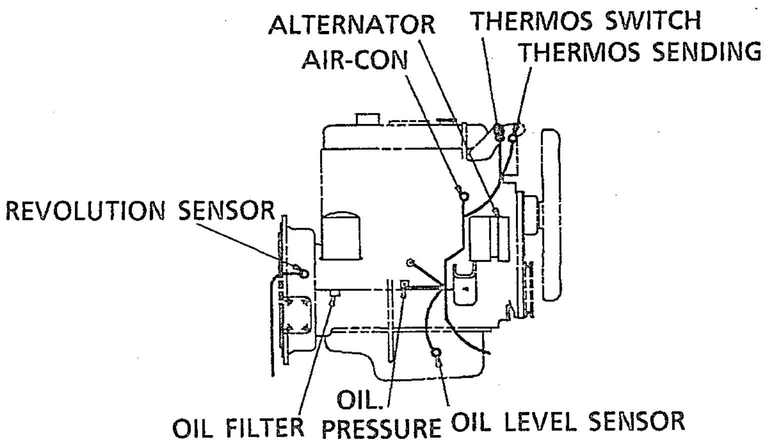

2
9
7
13
23
35
8
14
3
6
5
10
Starter side
BA(FOR M10) TERMINAL
II
TO CABIN
A
A
12
11
15
34
36

No.	NAME	Q'ty
2	BATTERY RELAY	1
3	WORKING LIGHT	1
4	WORKING LIGHT	1
5	WORKING LIGHT	1
6	HORN ASSY	1
7	BATTERY CABLE	1
8	BATTERY CABLE	1
9	BATTERY CABLE	1
10	BATTERY CABLE	1
11	WIRING HARNESS	1
12	WIRING HARNESS	1
13	WIRING HARNESS	1
14	HARNESSES	1
15	HARNESSES	1
16	HARNESSES	2
33	LAMP ASSY	1
34	LAMP ASSY	1
35	LAMP ASSY	1
36	LAMP ASSY (INST.)	1
60	WIRING HARNESS	1
61	CODE	1
62	WIRING HARNESS (CAB)	1
80	HARNESSES	1
81	HARNESSES	1
82	HARNESSES	1

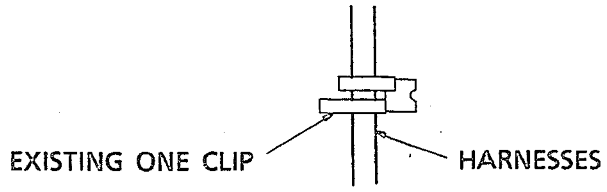
Note :
1. The tightening torque of the battery terminal to be 90~120 kg · cm (6.5~18.1 ft · lbs)


Wind insulator and insert into floor plate.

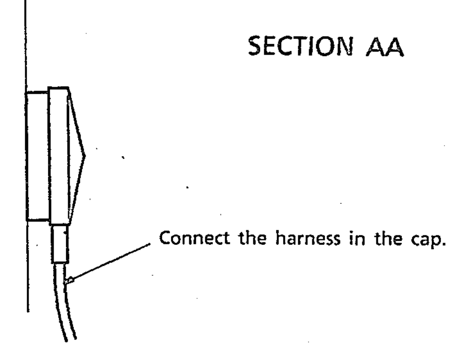
SECTION AA


ALTERNATOR
AIR-CON
THERMOS SWITCH
THERMOS SENDING
REVOLUTION SENSOR
OIL FILTER
OIL. PRESSURE
OIL LEVEL SENSOR

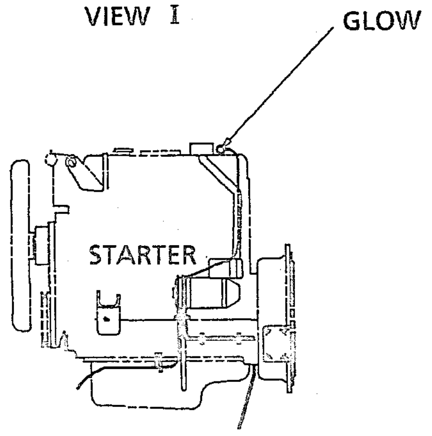
VIEW I


EXISTING ONE CLIP
HARNESSES

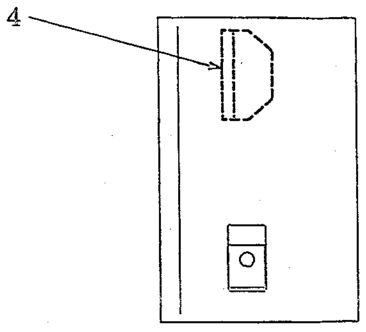
Fixing method harness


Connect the harness in the cap.

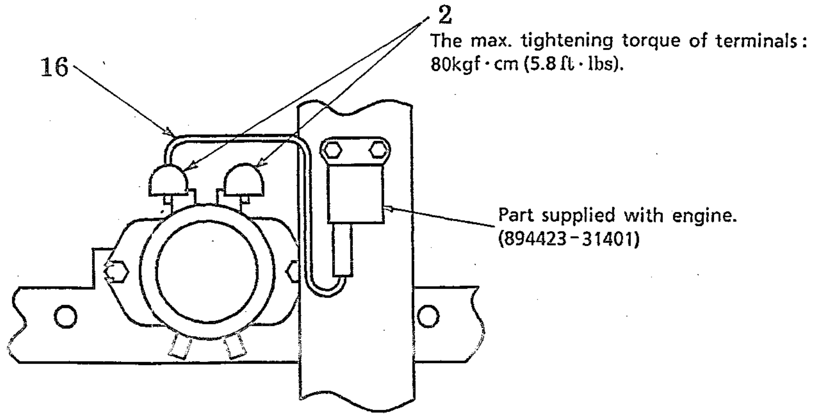
Detail of sending unit-fuel


GLOW
STARTER

VIEW II



Box section


2
The max. tightening torque of terminals: 80kgf · cm (5.8 ft · lbs).
16
Part supplied with engine. (894423-31401)

Detail of battery relay

輸出用
FOR EXPORT

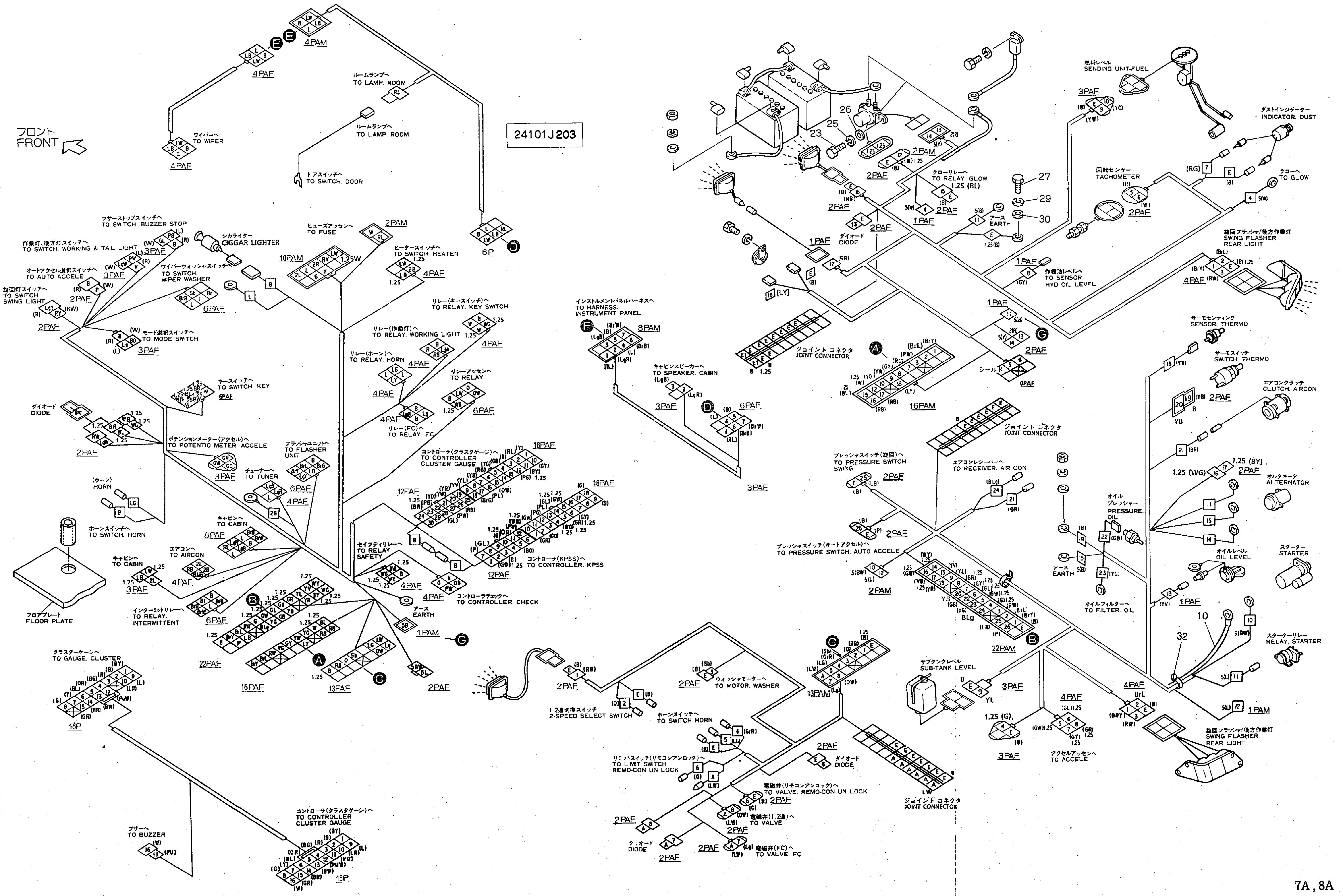
LE11001~

3.2 DETAILS OF WIRING HARNESSES

Applicable Models : LE11001~

デンキ ハイセン アッセン・WIRING ASSY, ELEC

24100J12458F2



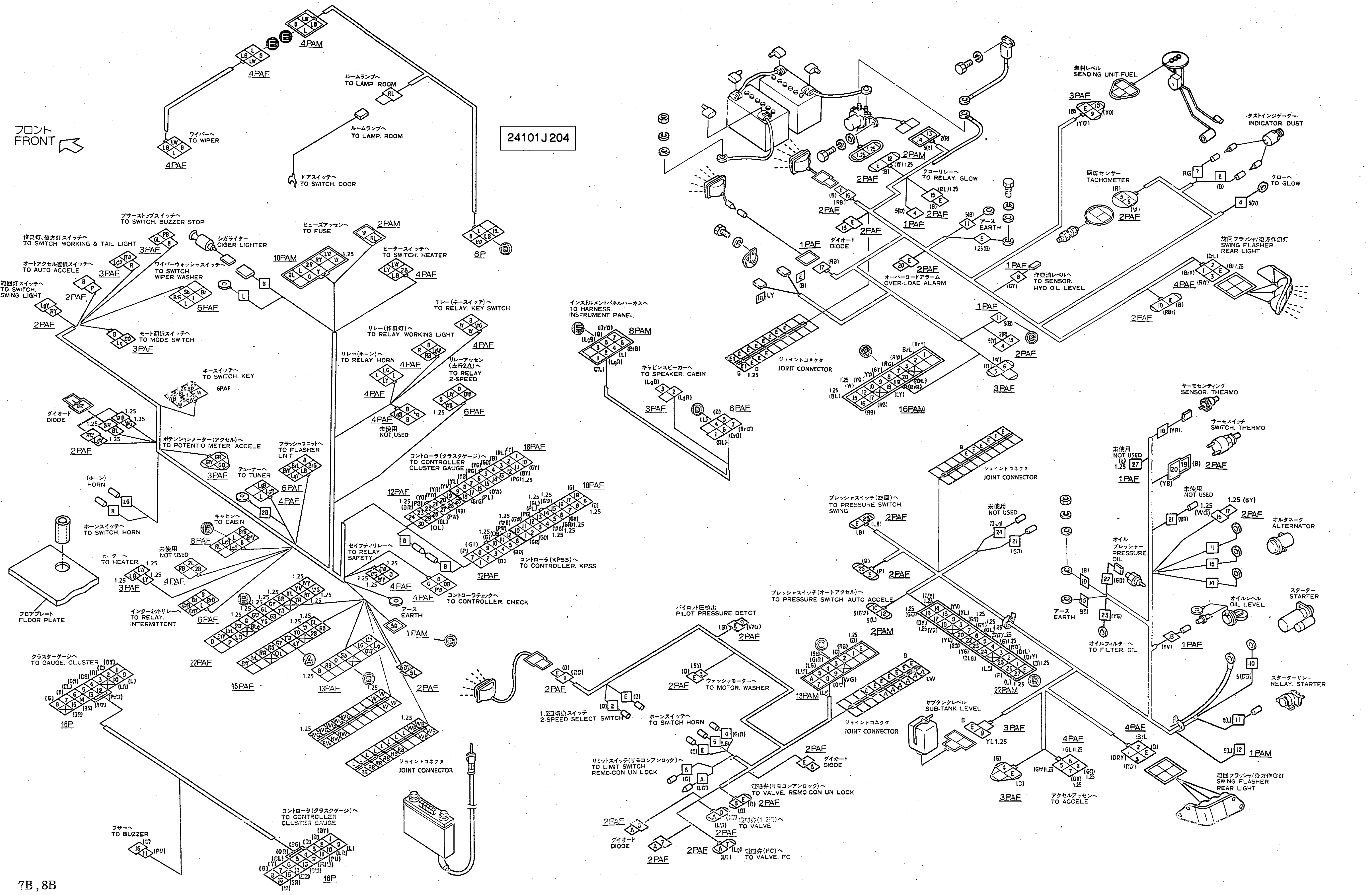
24101J203
フロント
FRONT
ワイパーへ
TO WIPER
4PAF
4PAM
ルームランプへ
TO LAMP. ROOM
ドアスイッチへ
TO SWITCH. DOOR
6P
ブザーストップスイッチへ
TO SWITCH. BUZZER STOP
シガライター
CIGGAR LIGHTER
ヒューズアッセンへ
TO FUSE
10PAM
2PAM
ヒータースイッチへ
TO SWITCH. HEATER
作業灯、後方灯スイッチへ
TO SWITCH. WORKING & TAIL LIGHT
3PAF
オートアクセル選択スイッチへ
TO AUTO ACCELE
ワイパーウォッシャスイッチへ
TO SWITCH. WIPER WASHER
旋回灯スイッチへ
TO SWITCH. SWING LIGHT
2PAF
6PAF
リレー(キースイッチ)へ
TO RELAY. KEY SWITCH
リレー(作業灯)へ
TO RELAY. WORKING LIGHT
モード選択スイッチへ
TO MODE SWITCH
リレー(ホーン)へ
TO RELAY. HORN
リレーアッセンへ
TO RELAY
キースイッチへ
TO SWITCH. KEY
ダイオード
DIODE
リレー(FC)へ
TO RELAY FC
ポテンショメーター(アクセル)へ
TO POTENTIO METER. ACCELE
フラッシャユニットへ
TO FLASHER UNIT
コントローラ(クラスタゲージ)へ
TO CONTROLLER CLUSTER GAUGE
18PAF
(ホーン)
HORN
チューナーへ
TO TUNER
12PAM
ホーンスイッチへ
TO SWITCH. HORN
キャビンへ
TO CABIN
8PAF
エアコンへ
TO AIRCON
セイフティリレーへ
TO RELAY SAFETY
コントローラ(KPSS)へ
TO CONTROLLER. KPSS
12PAF
インターミットリレーへ
TO RELAY. INTERMITTENT
コントローラチェックへ
TO CONTROLLER. CHECK
アース
EARTH
フロアプレート
FLOOR PLATE
22PAF
16PAF
13PAF
1PAM
クラスターゲージへ
TO GAUGE. CLUSTER
16P
ブザーへ
TO BUZZER
コントローラ(クラスタゲージ)へ
TO CONTROLLER CLUSTER GAUGE
インストルメントパネルハーネスへ
TO HARNESS. INSTRUMENT PANEL
8PAM
ジョイント コネクタ
JOINT CONNECTOR
キャビンスピーカーへ
TO SPEAKER. CABIN
16PAM
3PAF
23
24
25
26
27
28
29
30
クローリレーへ
TO RELAY. GLOW
アース
EARTH
ダイオード
DIODE
1PAF
燃料レベル
SENDING UNIT-FUEL
回転センサー
TACHOMETER
ダストインジケーター
INDICATOR. DUST
クローへ
TO GLOW
作動油レベルへ
TO SENSOR. HYD OIL LEVEL
旋回フラッシャ/後方作業灯
SWING FLASHER REAR LIGHT
4PAF
シールド
サーモセンディング
SENSOR. THERMO
サーモスイッチ
SWITCH. THERMO
エアコンクラッチ
CLUTCH. AIRCON
ジョイント コネクタ
JOINT CONNECTOR
プレッシャスイッチ(旋回)へ
TO PRESSURE SWITCH. SWING
エアコンレシーバーへ
TO RECEIVER. AIR CON
オルタネータ
ALTERNATOR
オイルプレッシャー
PRESSURE. OIL
プレッシャスイッチ(オートアクセル)へ
TO PRESSURE SWITCH. AUTO ACCELE
オイルレベル
OIL LEVEL
スターター
STARTER
アース
EARTH
オイルフィルターへ
TO FILTER. OIL
22PAM
スターターリレー
RELAY. STARTER
サブタンクレベル
SUB-TANK LEVEL
13PAM
ウォッシャモーターへ
TO MOTOR. WASHER
1.2速切換スイッチ
2-SPEED SELECT SWITCH
ホーンスイッチへ
TO SWITCH HORN
リミットスイッチ(リモコンアンロック)へ
TO LIMIT SWITCH REMO-CON UN LOCK
ダイオード
DIODE
電磁弁(リモコンアンロック)へ
TO VALVE. REMO-CON UN LOCK
電磁弁(1.2速)へ
TO VALVE
電磁弁(FC)へ
TO VALVE. FC
ダイオード
DIODE
ジョイント コネクタ
JOINT CONNECTOR
アクセルアッセンへ
TO ACCELE
旋回フラッシャ/後方作業灯
SWING FLASHER REAR LIGHT
10
32

欧州用
FOR EUROPE

LE11001~

デンキ ハイセン アッセン・WIRING ASSY, ELEC

24100J13207F3


24101J204
フロント
FRONT
ワイパーへ TO WIPER
4PAF
4PAM
ルームランプへ TO LAMP. ROOM
ドアスイッチへ TO SWITCH. DOOR
ブザーストップスイッチへ TO SWITCH. BUZZER STOP
作口灯, 役方灯スイッチへ TO SWITCH. WORKING & TAIL LIGHT
シガライター CIGER LIGHTER
オートアクセル選択スイッチへ TO AUTO ACCELE
ワイパーウォッシャスイッチへ TO SWITCH. WIPER WASHER
旋回灯スイッチへ TO SWITCH. SWING LIGHT
ヒューズアッセンへ TO FUSE
10PAM
ヒータースイッチへ TO SWITCH. HEATER
6P
モード選択スイッチへ TO MODE SWITCH
リレー(キースイッチ)へ TO RELAY. KEY SWITCH
リレー(作口灯)へ TO RELAY. WORKING LIGHT
リレー(ホーン)へ TO RELAY. HORN
リレーアッセン(走行2速)へ TO RELAY 2-SPEED
キースイッチへ TO SWITCH. KEY
ダイオード DIODE
未使用 NOT USED
ポテンショメーター(アクセル)へ TO POTENTIO METER. ACCELE
フラッシャユニットへ TO FLASHER UNIT
コントローラ(クラスタゲージ)へ TO CONTROLLER CLUSTER GAUGE
18PAF
12PAF
チューナーへ TO TUNER
(ホーン) HORN
ホーンスイッチへ TO SWITCH. HORN
キャビンへ TO CABIN
8PAF
ヒーターへ TO HEATER
セイフティリレーへ TO RELAY SAFETY
コントローラ(KPSS)へ TO CONTROLLER. KPSS
コントローラチェックへ TO CONTROLLER. CHECK
アース EARTH
フロアプレート FLOOR PLATE
インターミットリレーへ TO RELAY. INTERMITTENT
22PAF
16PAF
13PAF
1PAM
2PAF
クラスターゲージへ TO GAUGE. CLUSTER
16P
ジョイントコネクタ JOINT CONNECTOR
ブザーへ TO BUZZER
コントローラ(クラスタゲージ)へ TO CONTROLLER CLUSTER GAUGE
インスルメントパネルハーネスへ TO HARNESS. INSTRUMENT PANEL
8PAM
キャビンスピーカーへ TO SPEAKER. CABIN
3PAF
6PAF
ジョイントコネクタ JOINT CONNECTOR
16PAM
燃料レベル SENDING UNIT-FUEL
ダストインジゲーター INDICATOR. DUST
回転センサー TACHOMETER
グローへ TO GLOW
クローリレーへ TO RELAY. GLOW
アース EARTH
ダイオード DIODE
オーバーロードアラーム OVER-LOAD ALARM
作動油レベルへ TO SENSOR. HYD OIL LEVEL
旋回フラッシャ/役方作口灯 SWING FLASHER REAR LIGHT
サーモセンシング SENSOR. THERMO
サーモスイッチ SWITCH. THERMO
ジョイントコネクタ JOINT CONNECTOR
プレッシャスイッチ(旋回)へ TO PRESSURE SWITCH. SWING
未使用 NOT USED
オイルプレッシャー PRESSURE. OIL
オルタネータ ALTERNATOR
プレッシャスイッチ(オートアクセル)へ TO PRESSURE SWITCH. AUTO ACCELE
2PAM
22PAM
オイルレベル OIL LEVEL
スターター STARTER
オイルフィルターへ TO FILTER. OIL
スターターリレー RELAY. STARTER
パイロット圧検出 PILOT PRESSURE DETCT
ウォッシャモーターへ TO MOTOR. WASHER
1.2速切換スイッチ 2-SPEED SELECT SWITCH
ホーンスイッチへ TO SWITCH HORN
13PAM
サブタンクレベル SUB-TANK LEVEL
ジョイントコネクタ JOINT CONNECTOR
リミットスイッチ(リモコンアンロック)へ TO LIMIT SWITCH REMO-CON UN LOCK
ダイオード DIODE
電磁弁(リモコンアンロック)へ TO VALVE. REMO-CON UN LOCK
電磁弁(1.2速)へ TO VALVE
電磁弁(FC)へ TO VALVE. FC
アクセルアッセンへ TO ACCELE
旋回フラッシャ/役方作口灯 SWING FLASHER REAR LIGHT
4PAF
1PAF
1PAM

7B , 8B

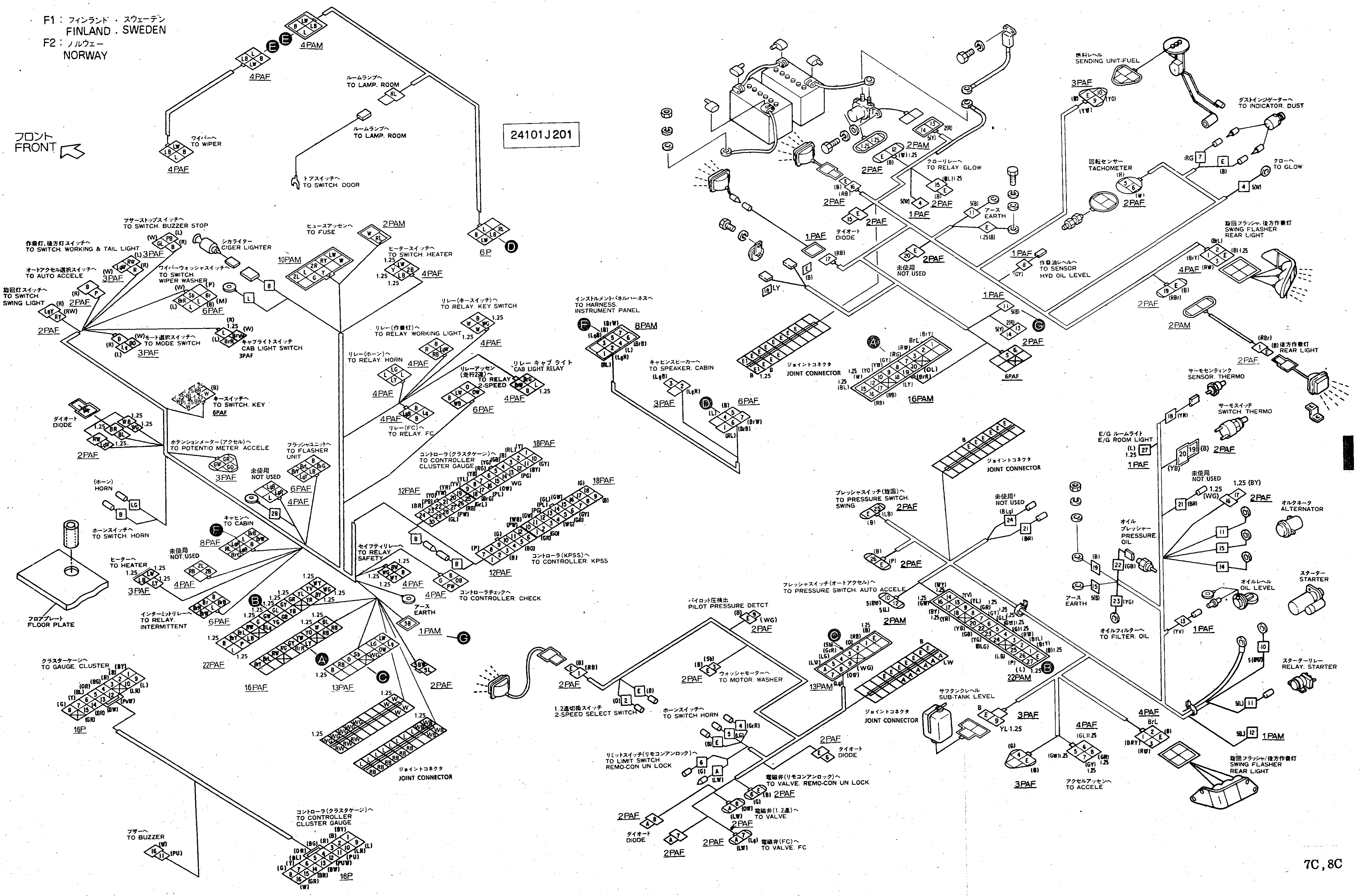
北　欧　用
FOR NORTH EUROPE

LE11001~

デンキ ハイセン アッセン・WIRING ASSY, ELEC

24100J13207F1・F2

F1：フィンランド・スウェーデン
FINLAND．SWEDEN
F2：ノルウェー
NORWAY



24101J201
フロント
FRONT
ワイパーへ TO WIPER
ルームランプへ TO LAMP, ROOM
ドアスイッチへ TO SWITCH, DOOR
ブザーストップスイッチへ TO SWITCH, BUZZER STOP
シガライター CIGER LIGHTER
作業灯、後方灯スイッチへ TO SWITCH, WORKING & TAIL LIGHT
オートアクセル選択スイッチへ TO AUTO ACCELE
ワイパーウォッシャスイッチへ TO SWITCH, WIPER WASHER
旋回灯スイッチへ TO SWITCH, SWING LIGHT
モード選択スイッチへ TO MODE SWITCH
キャブライトスイッチ CAB LIGHT SWITCH
ヒューズアッセンへ TO FUSE
ヒータースイッチへ TO SWITCH, HEATER
リレー(キースイッチ)へ TO RELAY, KEY SWITCH
リレー(作業灯)へ TO RELAY, WORKING LIGHT
リレー(ホーン)へ TO RELAY, HORN
リレーアッセン(走行2速)へ TO RELAY, 2-SPEED
リレー キャブ ライト CAB LIGHT RELAY
リレー(FC)へ TO RELAY, FC
キースイッチへ TO SWITCH, KEY
ダイオード DIODE
ポテンショメーター(アクセル)へ TO POTENTIO METER, ACCELE
フラッシャユニットへ TO FLASHER UNIT
未使用 NOT USED
コントローラ(クラスタゲージ)へ TO CONTROLLER, CLUSTER GAUGE
コントローラ(KPSS)へ TO CONTROLLER, KPSS
(ホーン) HORN
ホーンスイッチへ TO SWITCH, HORN
キャビンへ TO CABIN
ヒーターへ TO HEATER
セイフティリレーへ TO RELAY, SAFETY
コントローラチェックへ TO CONTROLLER, CHECK
アース EARTH
インターミットリレーへ TO RELAY, INTERMITTENT
フロアプレート FLOOR PLATE
クラスターゲージへ TO GAUGE, CLUSTER
ジョイントコネクタ JOINT CONNECTOR
ブザーへ TO BUZZER
インストルメントパネルハーネスへ TO HARNESS, INSTRUMENT PANEL
キャビンスピーカーへ TO SPEAKER, CABIN
パイロット圧検出 PILOT PRESSURE DETCT
ウォッシャモーターへ TO MOTOR, WASHER
1.2速切換スイッチ 2-SPEED SELECT SWITCH
ホーンスイッチへ TO SWITCH HORN
リミットスイッチ(リモコンアンロック)へ TO LIMIT SWITCH REMO-CON UN LOCK
電磁弁(リモコンアンロック)へ TO VALVE, REMO-CON UN LOCK
電磁弁(1.2速)へ TO VALVE
電磁弁(FC)へ TO VALVE, FC
プレッシャスイッチ(旋回)へ TO PRESSURE SWITCH, SWING
プレッシャスイッチ(オートアクセル)へ TO PRESSURE SWITCH, AUTO ACCELE
サブタンクレベル SUB-TANK LEVEL
アクセルアッセンへ TO ACCELE
旋回フラッシャ,後方作業灯 SWING FLASHER REAR LIGHT
燃料レベル SENDING UNIT-FUEL
ダストインジケーターへ TO INDICATOR, DUST
回転センサー TACHOMETER
グローへ TO GLOW
グローリレーへ TO RELAY, GLOW
作動油レベルへ TO SENSOR HYD OIL LEVEL
後方作業灯 REAR LIGHT
サーモセンディング SENSOR, THERMO
サーモスイッチ SWITCH, THERMO
E/G ルームライト E/G ROOM LIGHT
オルタネータ ALTERNATOR
オイルプレッシャー PRESSURE OIL
スターター STARTER
オイルレベル OIL LEVEL
オイルフィルターへ TO FILTER, OIL
スターターリレー RELAY, STARTER
1PAF
2PAF
3PAF
4PAF
6PAF
8PAF
10PAM
12PAF
13PAF
16PAF
18PAF
22PAF
1PAM
2PAM
4PAM
8PAM
13PAM
16PAM
22PAM
6P
16P

Book code No. S5LE2506E

KOBELCO

SHOP MANUAL SK60

ELECTRICAL SYSTEM

TABLE OF CONTENTS

1. LOCATION OF ELECTRICAL COMPONENTS

1.1 Control Board ·· 1

2. ELECTRICAL CIRCUIT DIAGRAMS ···················· 3

LE 25

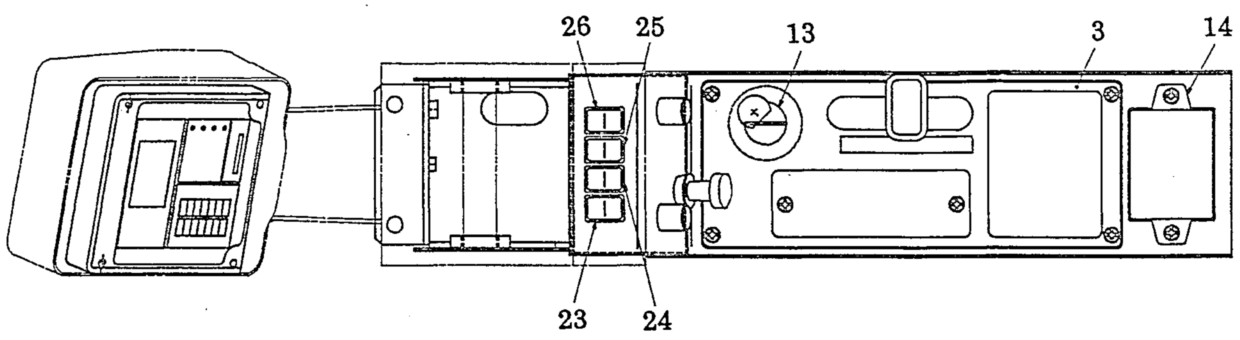
KOBE STEEL, LTD.

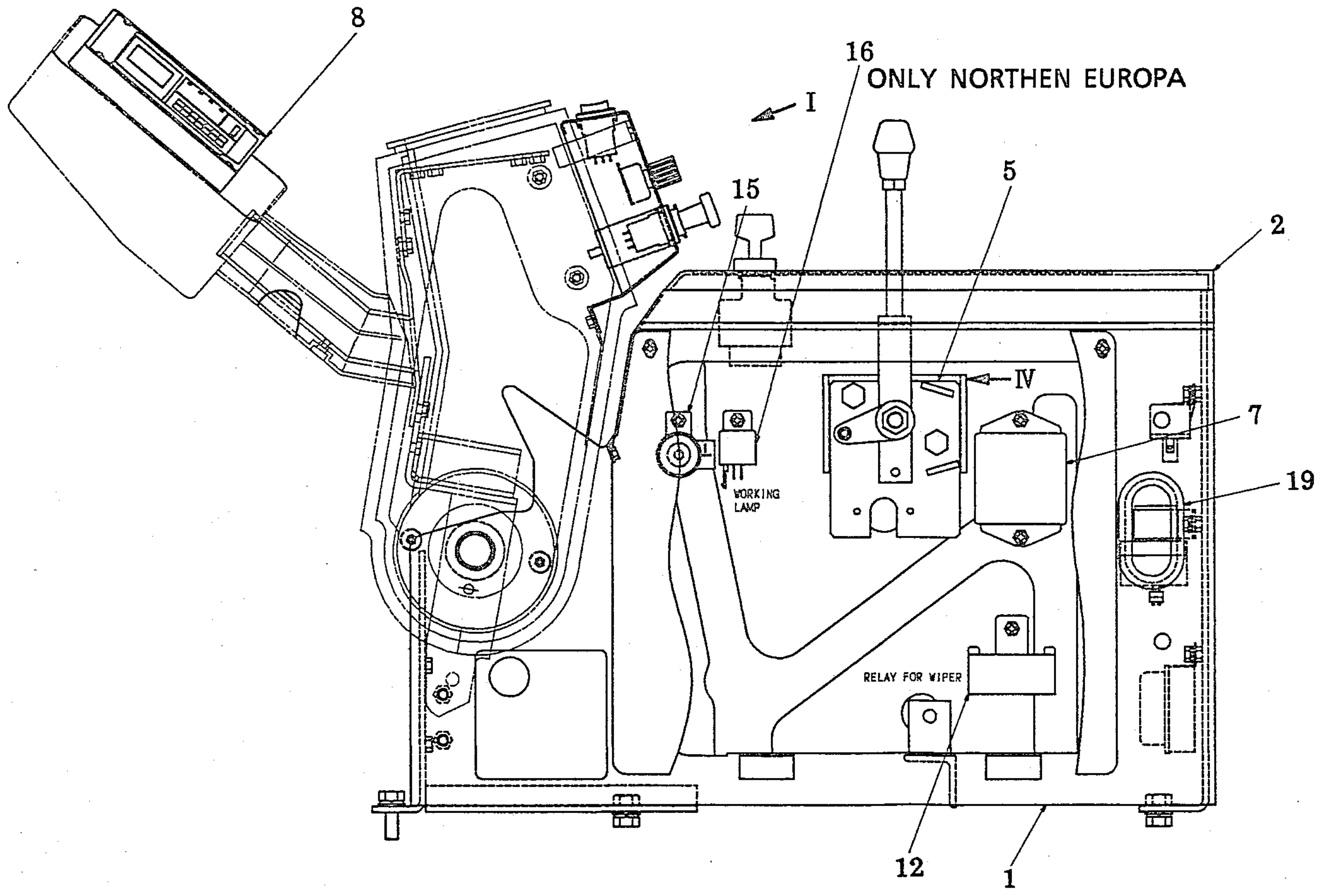
Applicable Machines
LE-14101~

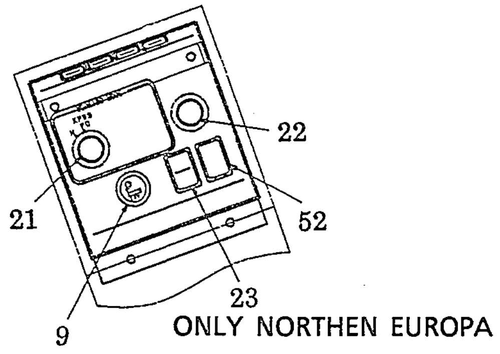
Revision	Date of Issue	Remarks
First edition	Decembre,1991	S5LE2506E K

1. LOCATION OF ELECTRICAL COMPONENTS

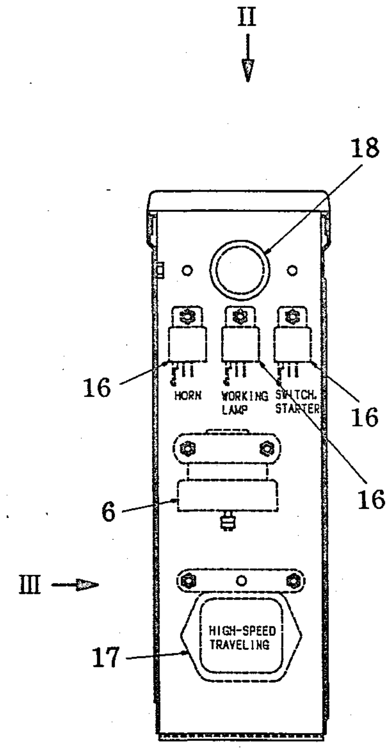
1.1 CONTROL BOARD


26
25
13
3
14
23
24

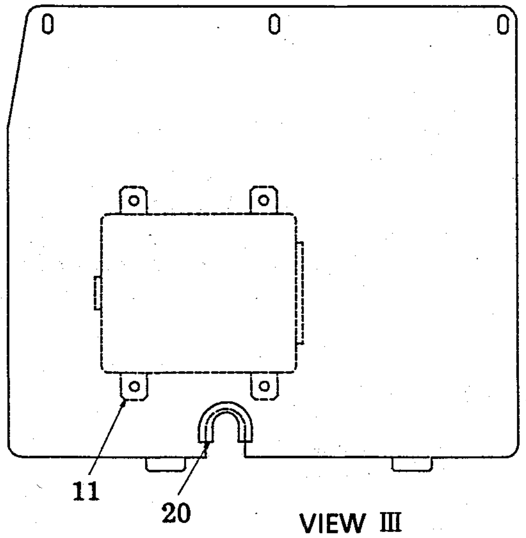

8
16
ONLY NORTHEN EUROPA
I
15
5
2
IV
7
19
WORKING LAMP
RELAY FOR WIPER
12
1


22
21
52
23
9
ONLY NORTHEN EUROPA

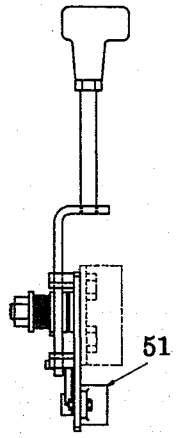
VIEW I


II
18
16
HORN
WORKING LAMP
SWITCH. STARTER
16
16
6
III
17
HIGH-SPEED TRAVELING

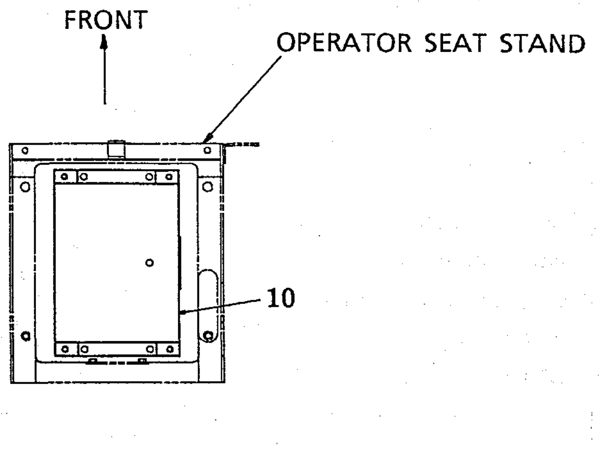
No.	NAME	NORTHEN EUROPA	EUROPA
		Q' ty	Q' ty
1	CONTROL STAND	1	1
2	INSTRUMENT PANEL	1	1
3	INSTRUMENT PANEL	1	1
5	THROTTLE LEVER ASSY	1	1
6	STARTER SAFETY RELAY	1	1
7	FLASHER UNIT	1	1
8	GAUGE CLUSTER	1	1
9	CIGARETTE LIGHTER	1	1
10	CONTROLLER ; KPSS	1	1
11	CONTROLLER ; GAUGE CLUSTER	1	1
12	INTERMIT RELAY	1	1
13	STARTER SWITCH	1	1
14	FUSE BOX	1	1
15	BUZZER	1	1
16	RELAY	4	3
17	RELAY ASSY	1	1
18	GROMMET	1	1
19	GROMMET	1	1
20	GROMMET	1	1
21	SWITCH ; MODE CHANGE	1	1
22	SWITCH ; WIPER	1	1
23	SWITCH ; WORKING LAMP	2	1
24	SWITCH ; SWING FLASHER	1	1
25	SWITCH ; AUTO - ACCEL	1	1
26	SWITCH ; BUZZER STOP	1	1
51	POTENTIONMETER	1	1
52	CAP	1	6



VIEW III



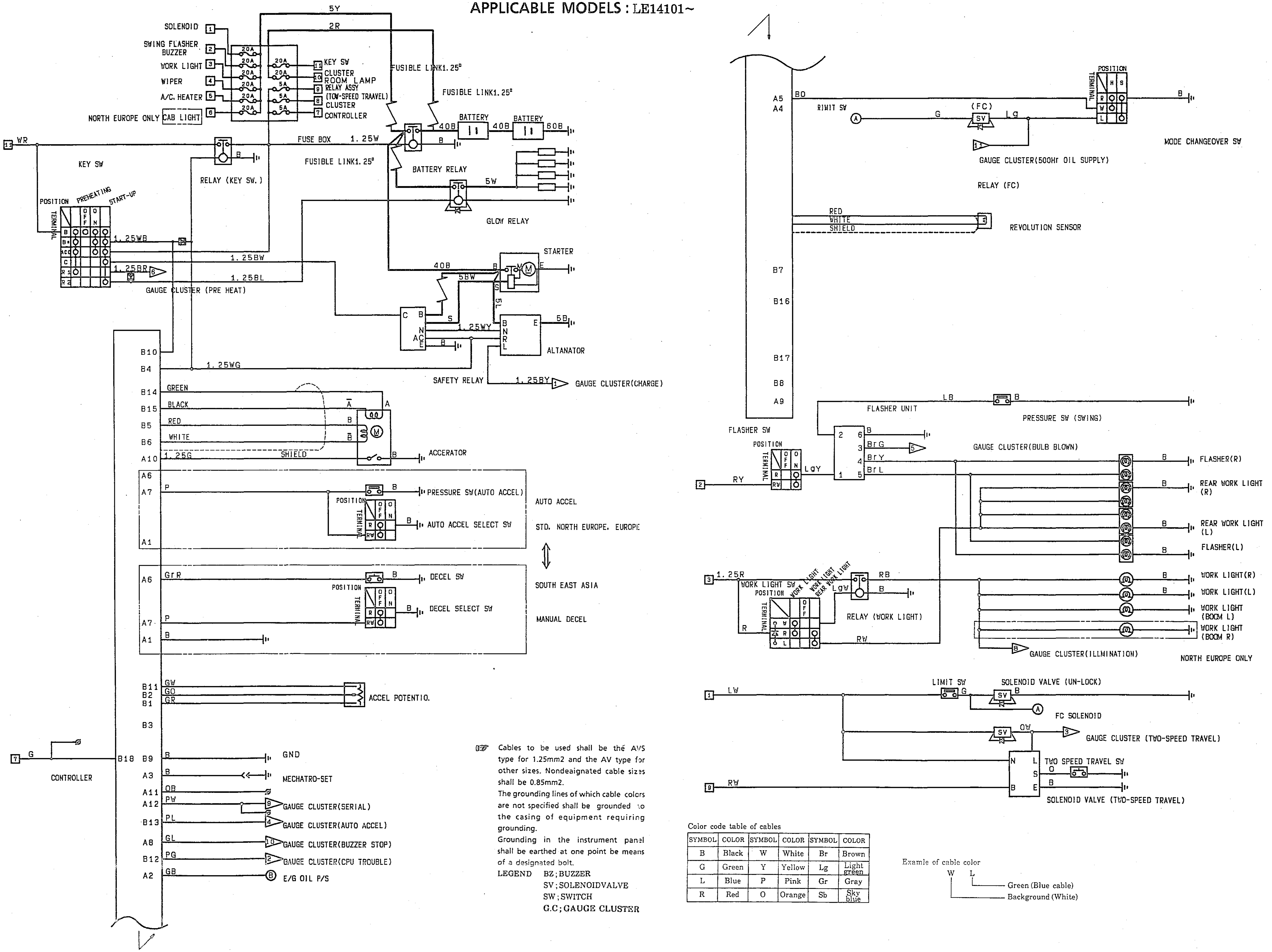
VIEW IV


FRONT
OPERATOR SEAT STAND
10

VIEW II

2. ELECTRICAL CIRCUIT DIAGRAMS

APPLICABLE MODELS : LE14101~


5Y
2R
SOLENOID
SWING FLASHER BUZZER
WORK LIGHT
WIPER
A/C. HEATER
NORTH EUROPE ONLY
CAB LIGHT
20A
5A
KEY SW
CLUSTER
ROOM LAMP
RELAY ASSY
(TOW-SPEED TRAVEL)
CLUSTER
CONTROLLER
FUSIBLE LINK1.25
FUSIBLE LINK1.25
BATTERY
BATTERY
40B
60B
FUSE BOX
1.25W
FUSIBLE LINK1.25
BATTERY RELAY
5W
GLOW RELAY
WR
KEY SW
RELAY (KEY SW.)
POSITION
PREHEATING
START-UP
TERMINAL
OFF
ON
B
BR
ACC
C
R1
R2
1.25WB
1.25BR
1.25BW
1.25BL
GAUGE CLUSTER (PRE HEAT)
STARTER
40B
5BW
5L
S
E
M
C
B
N
AC
E
1.25WY
5B
ALTANATOR
B
N
R
L
SAFETY RELAY
1.25BY
GAUGE CLUSTER(CHARGE)
B10
B4
1.25WG
B14
GREEN
B15
BLACK
B5
RED
B6
WHITE
A10
1.25G
SHIELD
ACCERATOR
A6
A7
A1
P
PRESSURE SW(AUTO ACCEL)
AUTO ACCEL SELECT SW
AUTO ACCEL
STD. NORTH EUROPE. EUROPE
GrR
DECEL SW
DECEL SELECT SW
SOUTH EAST ASIA
MANUAL DECEL
B11
B2
B1
GW
GO
GR
ACCEL POTENTIO.
B3
G
CONTROLLER
B18
B9
GND
A3
MECHATRO-SET
A11
OB
A12
PW
GAUGE CLUSTER(SERIAL)
B13
PL
GAUGE CLUSTER(AUTO ACCEL)
A8
GL
GAUGE CLUSTER(BUZZER STOP)
B12
PG
GAUGE CLUSTER(CPU TROUBLE)
A2
GB
E/G OIL P/S
A5
A4
BO
RIMIT SW
G
(FC)
SV
Lg
GAUGE CLUSTER(500Hr OIL SUPPLY)
RELAY (FC)
POSITION
H
S
MODE CHANGEOVER SW
RED
WHITE
SHIELD
REVOLUTION SENSOR
B7
B16
B17
B8
A9
LB
PRESSURE SW (SWING)
FLASHER UNIT
FLASHER SW
RY
LgY
BrG
BrY
BrL
GAUGE CLUSTER(BULB BLOWN)
FLASHER(R)
REAR WORK LIGHT (R)
REAR WORK LIGHT (L)
FLASHER(L)
1.25R
WORK LIGHT SW
WORK LIGHT
WORK LIGHT
REAR WORK LIGHT
RB
LgW
RELAY (WORK LIGHT)
RW
WORK LIGHT(R)
WORK LIGHT(L)
WORK LIGHT (BOOM L)
WORK LIGHT (BOOM R)
GAUGE CLUSTER(ILLMINATION)
NORTH EUROPE ONLY
LW
LIMIT SW
SOLENOID VALVE (UN-LOCK)
FC SOLENOID
OW
GAUGE CLUSTER (TWO-SPEED TRAVEL)
TWO SPEED TRAVEL SW
RW
SOLENOID VALVE (TWO-SPEED TRAVEL)

☞ Cables to be used shall be the AVS type for $1.25mm^2$ and the AV type for other sizes. Nondeaignated cable sizes shall be $0.85mm^2$.

The grounding lines of which cable colors are not specified shall be grounded to the casing of equipment requiring grounding.

Grounding in the instrument panel shall be earthed at one point be means of a designated bolt.

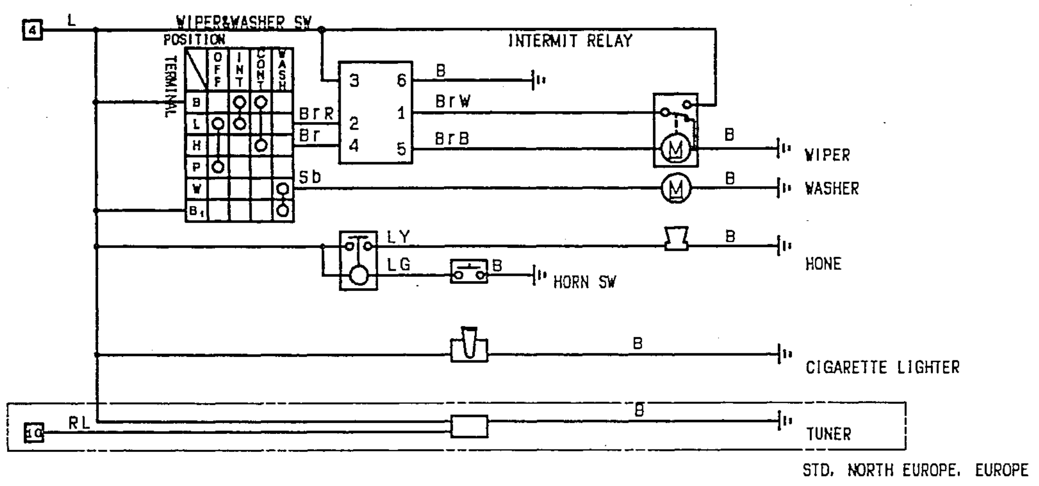
LEGEND BZ;BUZZER
SV;SOLENOIDVALVE
SW;SWITCH
G.C;GAUGE CLUSTER

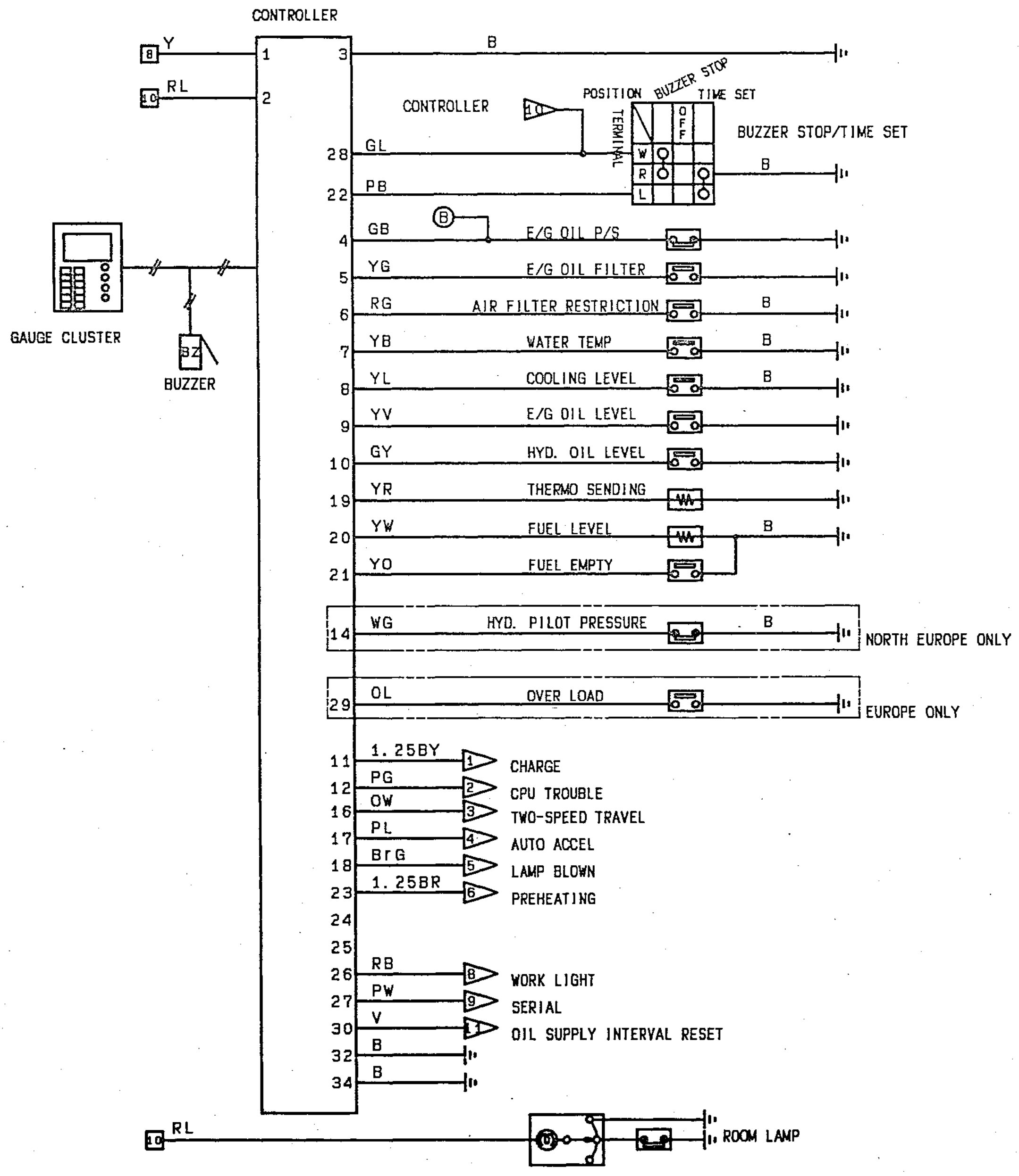
Color code table of cables

SYMBOL	COLOR	SYMBOL	COLOR	SYMBOL	COLOR
B	Black	W	White	Br	Brown
G	Green	Y	Yellow	Lg	Light green
L	Blue	P	Pink	Gr	Gray
R	Red	O	Orange	Sb	Sky blue

Examle of cable color

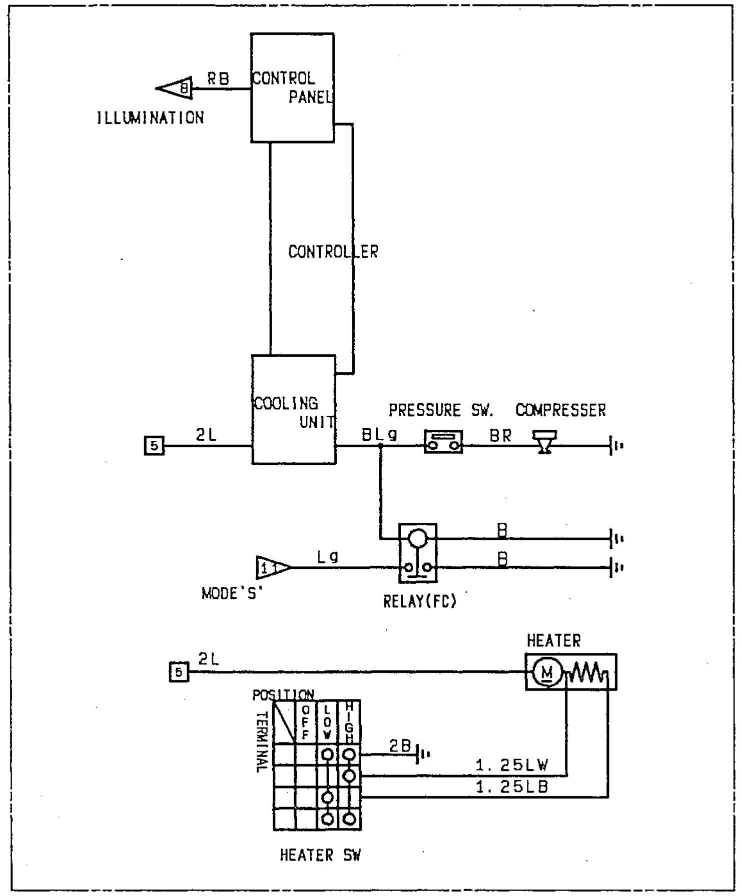
W L
Green (Blue cable)
Background (White)


4
L
WIPER&WASHER SW
POSITION
TERMINAL
OFF
INT
CONT
WASH
B
L
H
P
W
B1
INTERMIT RELAY
3
2
4
6
1
5
BrR
Br
B
BrW
BrB
Sb
B
WIPER
WASHER
LY
LG
B
HORN SW
HONE
CIGARETTE LIGHTER
10
RL
TUNER
STD. NORTH EUROPE, EUROPE

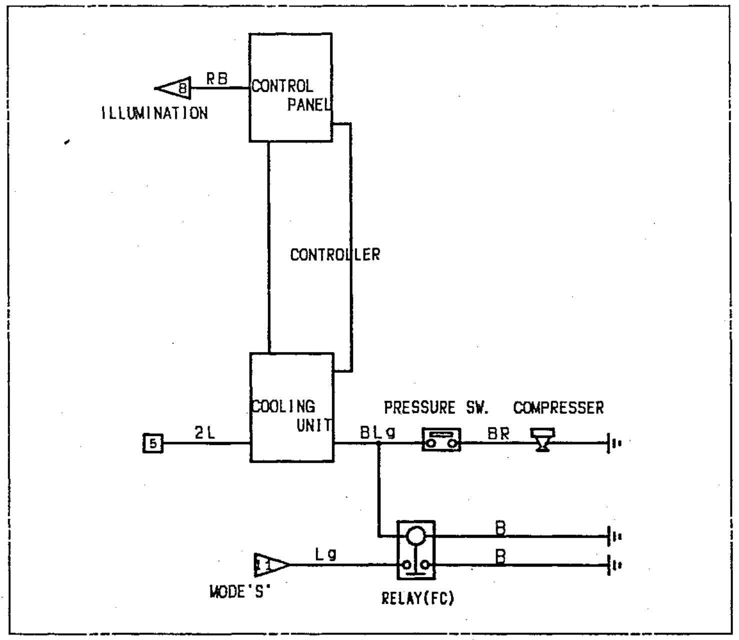

CONTROLLER
8
Y
10
RL
1
2
3
B
CONTROLLER
10
POSITION
BUZZER STOP
TIME SET
TERMINAL
OFF
W
R
L
BUZZER STOP/TIME SET
28 GL
22 PB
GAUGE CLUSTER
BZ
BUZZER
4 GB
E/G OIL P/S
5 YG
E/G OIL FILTER
6 RG
AIR FILTER RESTRICTION
7 YB
WATER TEMP
8 YL
COOLING LEVEL
9 YV
E/G OIL LEVEL
10 GY
HYD. OIL LEVEL
19 YR
THERMO SENDING
20 YW
FUEL LEVEL
21 YO
FUEL EMPTY
14 WG
HYD. PILOT PRESSURE
NORTH EUROPE ONLY
29 OL
OVER LOAD
EUROPE ONLY
11 1.25BY
CHARGE
12 PG
CPU TROUBLE
16 OW
TWO-SPEED TRAVEL
17 PL
AUTO ACCEL
18 BrG
LAMP BLOWN
23 1.25BR
PREHEATING
24
25
26 RB
WORK LIGHT
27 PW
SERIAL
30 V
OIL SUPPLY INTERVAL RESET
32 B
34 B
10
RL
ROOM LAMP

SPEC. FOR CUSTOMERS

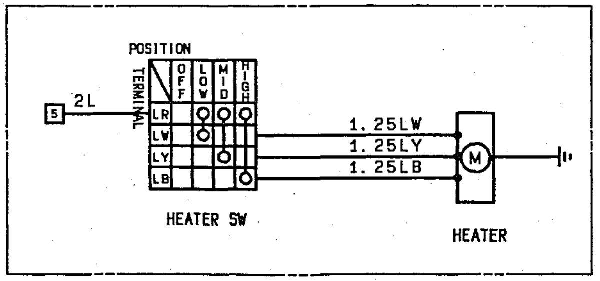
OCEANIA


RB
ILLUMINATION
CONTROL PANEL
CONTROLLER
COOLING UNIT
5
2L
PRESSURE SW.
COMPRESSER
BLg
BR
B
B
Lg
MODE'S'
RELAY(FC)
HEATER
5
2L
POSITION
TERMINAL
OFF
LOW
HIGH
2B
1.25LW
1.25LB
HEATER SW

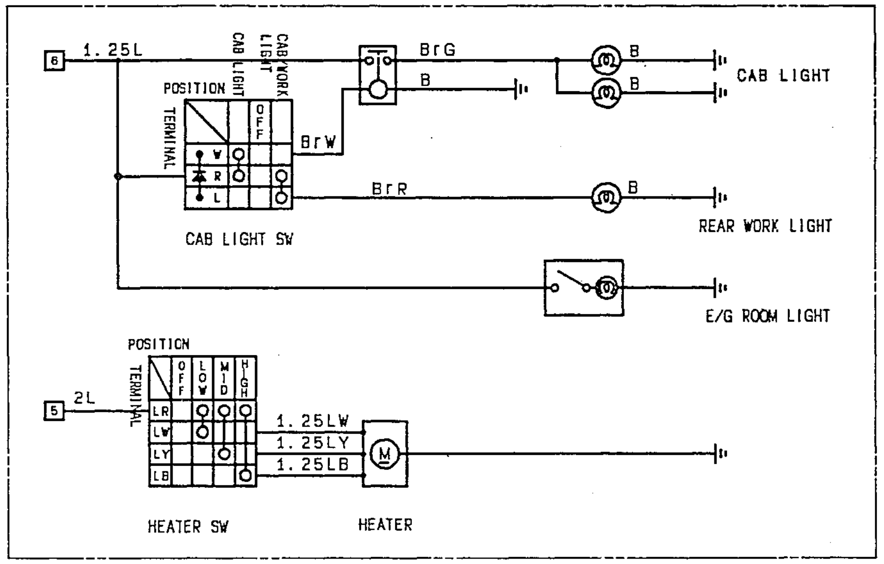
SOUTH EAST ASIA


RB
ILLUMINATION
CONTROL PANEL
CONTROLLER
COOLING UNIT
5
2L
PRESSURE SW.
COMPRESSER
BLg
BR
B
B
Lg
MODE'S'
RELAY(FC)

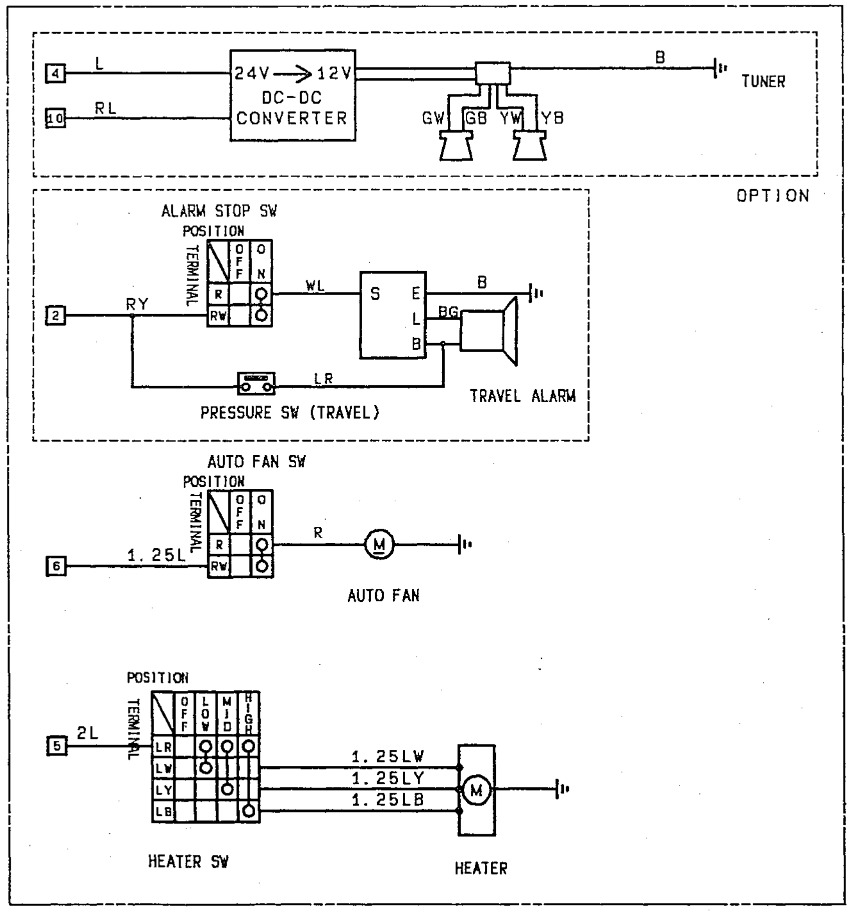
EUROPE


POSITION
TERMINAL
OFF
LOW
MID
HIGH
5
2L
LR
LW
LY
LB
1.25LW
1.25LY
1.25LB
M
HEATER SW
HEATER

NORTH EUROPE


6
1.25L
CAB LIGHT
CAB/WORK LIGHT
POSITION
TERMINAL
OFF
W
R
L
BrG
B
B
B
CAB LIGHT
BrW
BrR
B
REAR WORK LIGHT
CAB LIGHT SW
E/G ROOM LIGHT
POSITION
TERMINAL
OFF
LOW
MID
HIGH
5
2L
LR
LW
LY
LB
1.25LW
1.25LY
1.25LB
HEATER SW
HEATER

KAI


4
L
10
RL
24V → 12V
DC-DC CONVERTER
B
TUNER
GW
GB
YW
YB
OPTION
ALARM STOP SW
POSITION
TERMINAL
OFF
ON
R
RW
2
RY
WL
S
E
L
B
BG
B
LR
PRESSURE SW (TRAVEL)
TRAVEL ALARM
AUTO FAN SW
POSITION
TERMINAL
OFF
ON
R
RW
6
1.25L
R
AUTO FAN
POSITION
TERMINAL
OFF
LOW
MID
HIGH
5
2L
LR
LW
LY
LB
1.25LW
1.25LY
1.25LB
HEATER SW
HEATER

BooK code No. S5LE2601E

KOBELCO

SHOP MANUAL SK60

AIR CONDITIONING SYSTEM

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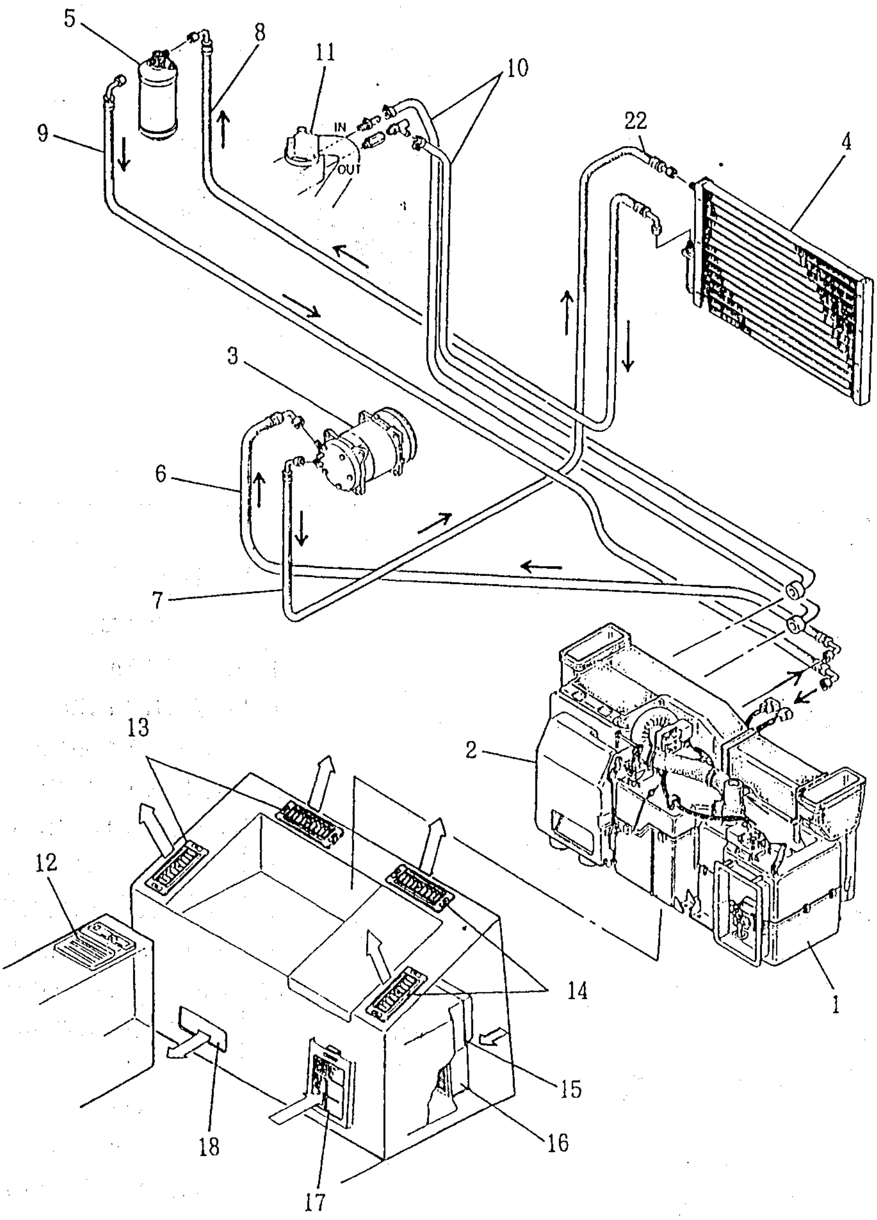
KOBE STEEL, LTD.

Applicable Machines
LE-11001~

Revision status	Date of issue	Remarks
First issue	June,1990	S5LE2601E K

1. CONSTRUCTION

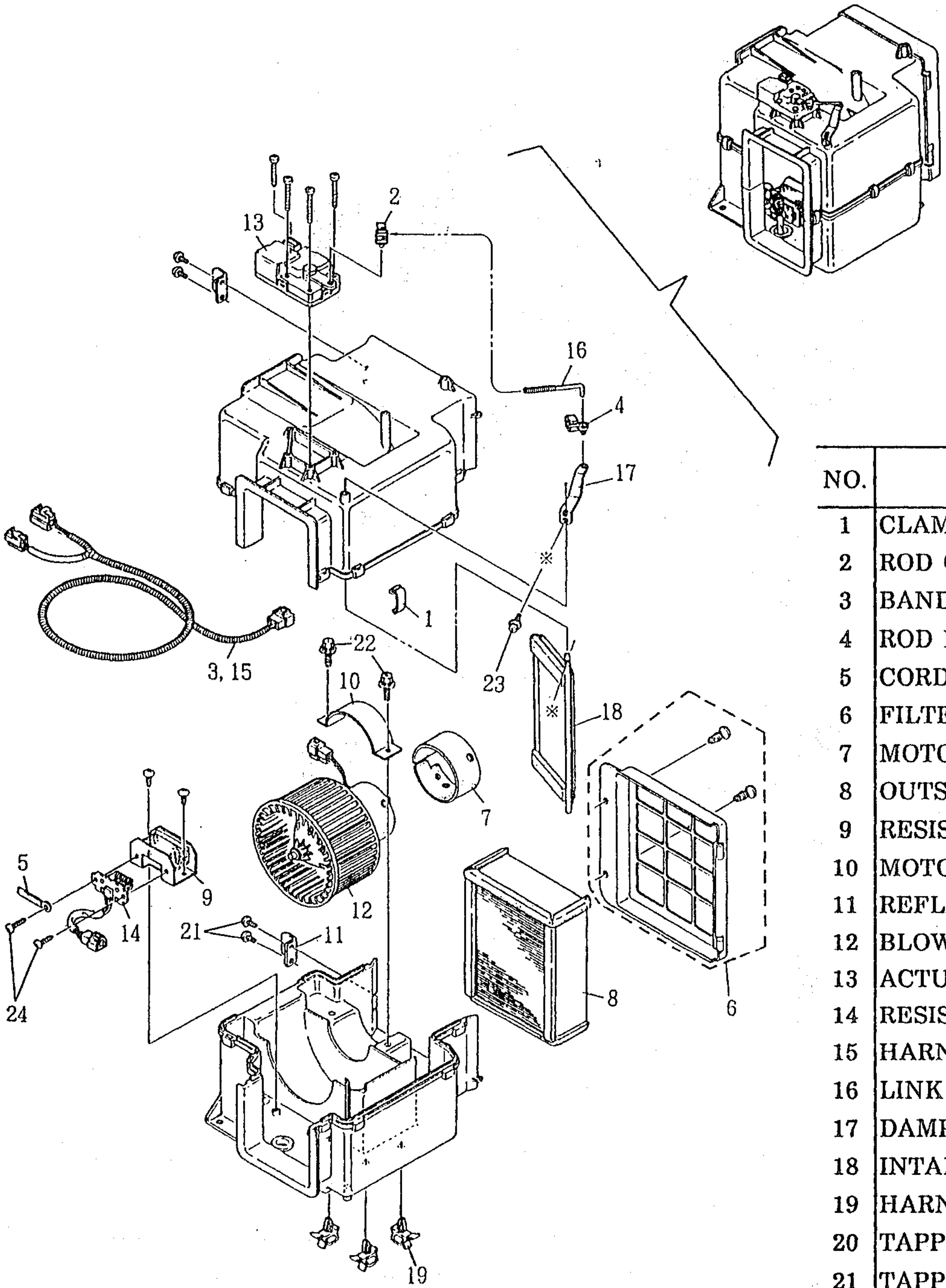

5
8
11
10
IN
OUT
9
22
4
3
6
7
13
2
12
14
1
15
18
16
17

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
1	INTAKE UNIT	1	7	D HOSE	1	13	TOP BLOWOUT HOLE	2
2	AIR CONDITIONING UNIT	1	8	L HOSE	1	14	TOP BLOWOUT HOLE	2
3	COMPRESSOR	1	9	L HOSE	1	15	AIR INTAKE	1
4	CONDENSER	1	10	COOLING WATER HOSE	2	16	AIR FILTER	1
5	RECEIVER DRYER	1	11	ENGINE	1	17	INSIDE AIR INTAKE (INSIDE AIR FILTER)	1
6	S HOSE	1	12	INSTRUMENT PANEL	1	18	BOTTOM BLOWOUT	1

Fig. 1

2. CONSTRUCTION OF MAIN COMPONENTS

2.1 INTAKE UNIT



NO.	NAME	Q'ty
1	CLAMP	10
2	ROD CLAMP	1
3	BAND 13A	1
4	ROD HOLDER	1
5	CORD CLAMP A	1
6	FILTER COVER	1
7	MOTOR CUSHION	1
8	OUTSIDE AIR FILTER	1
9	RESISTOR COVER	1
10	MOTOR RETAINER	1
11	REFLATCH HOLDER	2
12	BLOWER MOTOR	1
13	ACTUATOR A	1
14	RESISTOR	1
15	HARNESS (INTAKE)	1
16	LINK ROD (INTAKE)	1
17	DAMPER LEVER(INTAKE)	1
18	INTAKE DAMPER	1
19	HARNESS CLAMP	3
20	TAPPING SCREW	4
21	TAPPING SCREW	6
22	WASHER-ATTACHED BOLT	2
23	WASHER-ATTACHED BOLT	1
24	TAPPING SCREW	2

Fig. 2

2.2 AIR-CONDITIONER UNIT

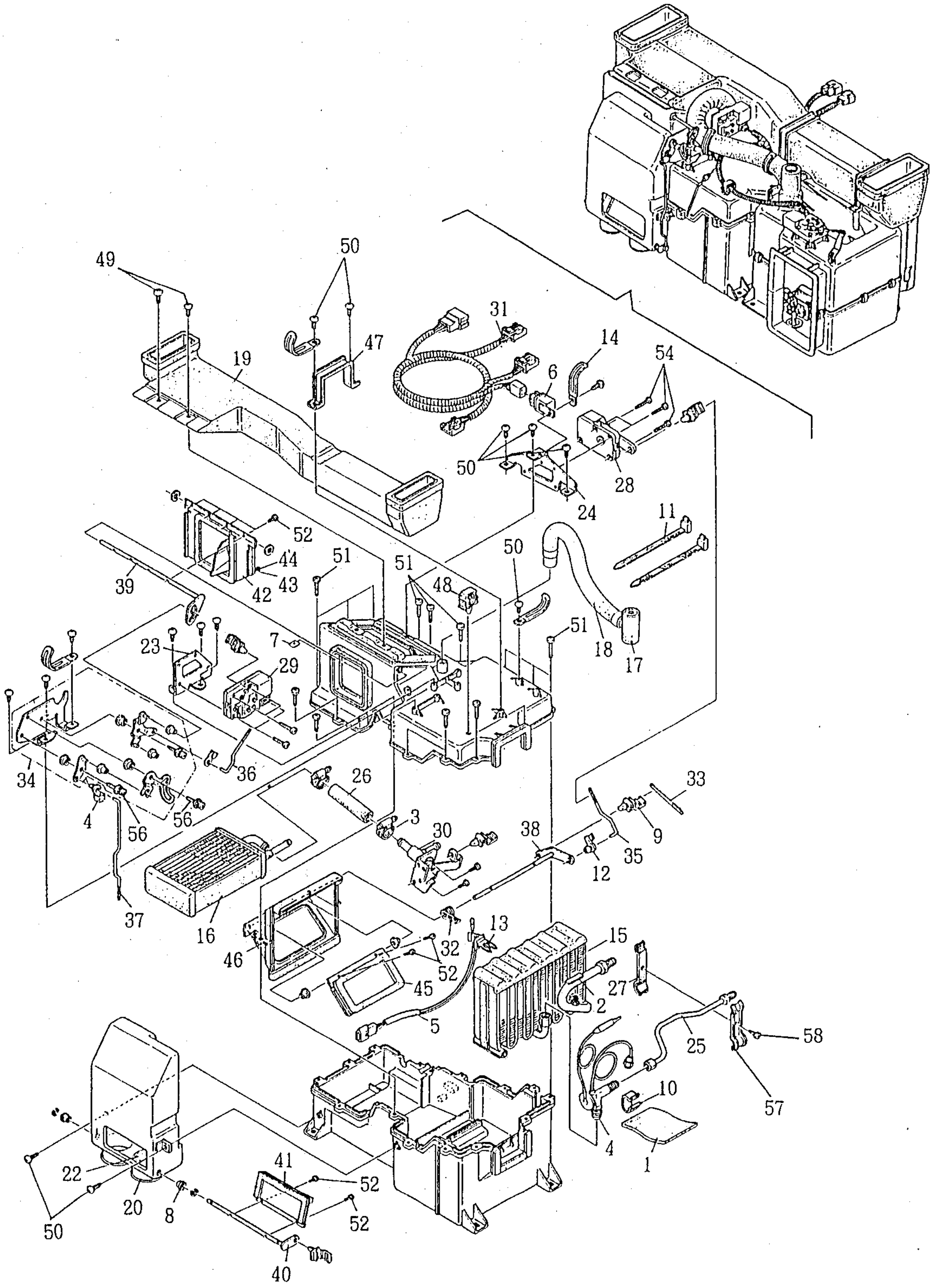
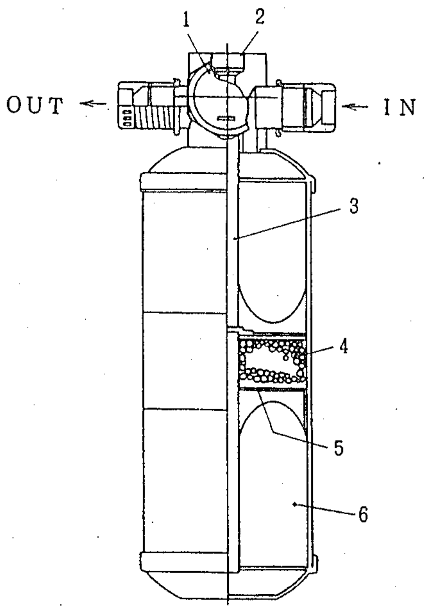

50
49
31
14
54
47
19
6
50
28
24
11
52
44
51
51
50
48
43
42
39
7
51
18
17
23
29
36
34
26
33
4
56
56
3
30
38
9
35
12
37
16
13
32
15
46
52
27
45
2
5
25
58
10
57
4
1
41
22
52
20
8
52
50
40

Fig. 3 (1/2)

No.	NOMENCLATURE	Q'ty	No.	NOMENCLATURE	Q'ty	No.	NOMENCLATURE	Q'ty
1	HEAT INSULATION MATERIAL G IN THE TEMPER-ATURE SENSING SECTION	1	20	LOWER DUCT	1	40	DAMPER SHAFT (DEAF)	1
2	THERMOWELL A	1	22	DEFLECTION PLUG	2	41	DEAF DAMPER	1
3	HOSE BAND	2	23	ACTUATOR BRACKET (MODE)	1	42	MODE DAMPER	1
4	S EXPANSION VALVE 1.5T	1	24	ACTUATO RBRACKET (AIR MIX)	1	43	COIL SPRING	1
5	THERMISTER C19	1	25	INLET PIPE	1	44	SPRING GUIDE	1
6	RELAY 24-4PA	1	26	HEATER HOSE	1	45	AIR MIX DAMPER	1
7	SPEED NUT T4	2	27	PIPE RETAINER A	1	46	DAMPER BASE	1
8	SPACER C	4	28	ACTUATOR A	1	47	DUCT RETAINER	1
9	ROD CLAMP	5	29	ACTUATOR B	1	48	HARNESS CLAMP	1
10	THERMOWELL STAY E	1	30	WATER VALVE	1	49	T4 TAPPING SCREW	2
11	BAND 13A	4	31	HARNESS (UNIT)	1	50	T5 TAPPING SCREW	17
12	ROD HOLDER	3	32	SPRING	1	51	SCREW	15
13	SENSOR HOLDER	1	33	VALVE ROD	1	52	SCREW	9
14	CORD FASTENER CA	3	34	MODE LINK ASS'Y	1	53	LINK AXLE	3
15	EVAPORATOR	1	35	LINK ROD (AIR MIX)	1	54	SCREW	8
16	HEATER CORE	1	36	LINK ROD (MODE)	1	55	SCREW	2
17	COOL BOX DUCT	1	37	LINK ROD (DEAF)	1	56	WASHER-ATTACHED BOLT	4
18	DUCT HOSE	1	38	DAMPER SHAFT (AIR MIX)	1	57	PIPE RETAINER B	1
19	UPPER DUCT	1	39	DAMPER SHAFT(MODE)	1	58	SCREW	1

Fig. 3 (2/2)

2.3 RECEIVER DRYER



1 PRESSURE SWITCH
2 SIGHT GLASS
3 SIPHON
4 DRYER (DESICCANT)
5 FILTER
6 RECEIVER TANK

Fig. 4

3. FUNCTION

3.1 MECHANISM OF THE COOLING CIRCUIT

(1) How cooling is performed

In the cooling action, coolant flowing in the cooling circuit transfers heat from the low temperature part (in the vehicle) to the high temperature part (outside the vehicle) as the coolant repeats changes of states from liquid to gas to liquid to gas.

1) Kind of coolant

Coolant acting like that comes in many kinds, but the following requirements are needed for general application.

- Large latent heat of vaporization (evaporation heat).
- Ease in liquefaction (condensation) (Too high pressure shall not be necessary for condensation.)
- Ease in gasification (evaporation) (Sufficient evaporation shall occur at not too low pressure and cool an object.)
- Small specific heat capacity. (Since the coolant is cooled by it self by the expansion valve, the loss caused by it must be held low.)
- The critical temperature shall be high and the freezing point be f low.
- Chemically stable, it shall not be corrosive nor penetrable to circuit parts.
- It offers no toxicity, objectionable odor, flammability and explosiveness and excels in thermal conductivity and electric insulation.
- Specific volume is small.
- Leakage must be easy to locate.

Out of those coolants that satisfy the above-mentioned requirements, one having characteristics suited for the objectives of the cooler is selected.

Therefore, if a coolant other than those specified is used, sufficient refrigeration may not be performed and the equipment may be broken. For this reason, always use a designated coolant for the cooler.

Table 1 shows the principal characteristics of a typical coolant Fron R-12.

Table 1

Chemical formula		$CC\ell_2F_2$
Molecular weight		120.92
Boiling point at 1 atm (°C)		−29.8
Freezing point (°C)		−158
Critical point	Temperature (°C)	111.5
	Pressure (kg/cm^2abs)	
	Capacity (cc/mol)	
	Density (g/cc)	
Specific gravity (with 30°C liquid) (g/cc)		
Specific gravity (saturated steam at boiling point) (g/ℓ)		
Specific heat (30°C liquid) (cal/g°C)		
Evaporation heat at boiling point (cal/g)		
Flammability		
Toxicity		No harm
Working temperature range		−20~10°C

(2) CHARACTERISTICS OF COOLANT (SEE FIG. 5.)

In general fluids (a general term for gas and liquid) have the following properties.

1) If the temperature of a gas under certain pressure is lowered, the gas begins to condense at a certain temperature and changes itself to a liquid state. There is only one point of temperature at which a substance (fluid) changes to a liquid state once pressure is given. The temperature determined by this pressure is called saturation temperature.
2) Contrary to it, a pressure at which a gas condenses at a certain temperature is determined. This pressure is called saturation pressure. Fig.5 is a graphed relationship between the saturation temperature and the saturation pressure of coolant R-12 which is used in the air conditioner. In fig.5, the coolant is in a liquid state at the temperature and the pressure range on the lower righthand side of the curve, while it is in a gaseous state at the temperature and pressure ranges on the upper lefthand side of the curve. Let us think about the condition of an air conditioner in the summer time. Since the coolant absorbs evaporation heat from the air in the vehicle when it evaporates, the coolant must change (evaporate) to gas from liquid at a temperature lower than that to cool the cabin to about 25°C (77°F). It can be seen from fig.5 that R-12 is a coolant which is sufficiently suited to cool the cabin interior at pressures over atmospheric condition. If you use a coolant that requires a pressure condition below atmosphere to cool it to a required temperature, air intrudes into the circuit and degrades the ability of the cooling machine. In a process in which gaseous coolant is reduced to liquid state, the coolant is cooled and condensed by outer air of more than 35°C (95°F). Therefore, as seen from fig.5, the coolant can be condensed at pressures exceeding 7.6kg/ cm^2G (108 psi).

Table 1

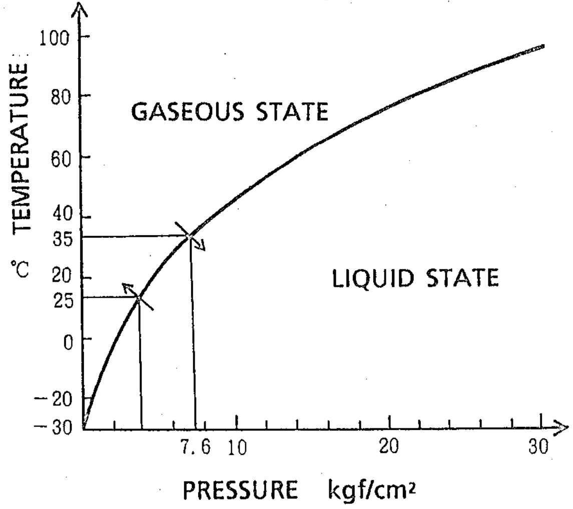


Fig. 5 Relationship of R-12 between saturation pressure and saturation temperature

3.2 COOLING CIRCUIT

Fig.6 shows the cooling circuit of a car air-conditioner.

In this circuit the section which is cooling the object air in the cabin is the evaporator. The object is cooled as the cooling circuit utilizes the action of coolant that absorbs heat from the circumference as evaporation heat as it evaporates. Since the area at which the evaporation of coolant is executed is the evaporator, air requiring cooling is constantly charged around the evaporator by the blower fan.

The effect of "cooling" is attained only when coolant in a liquid state (wet steam-state coolant not dried enough) is supplied into the evaporator.

For instance, in order to cool air to 15°C (59°F), coolant must evaporate at a temperature lower than 15°C (59°F). Otherwise the coolant can not absorb the evaporation heat. It can be seen from fig. 5 that the pressure of the coolant in the evaporator must fall below 4kg/cm^{2}G (56.9 psiG).

The cooling effect will be degraded unless the coolant supply is controlled so all the coolant supplied to the evaporator evaporates in the evaporator and becomes dry vapor. Therefore, the cooling circuit is so constructed that the evaporator can cool an object (air in this case) sufficiently and that a proper amount of coolant is supplied to the evaporator by lowering the pressure in the evaporator.

The feed rate of coolant is controlled by the expansion valve, but is held low by a combination of the throttling action of the expansion valve with the suction action of the compressor. The compressor works as a pump that circulates the coolant. The coolant in dry state returns to a liquid state once again by a combination of the compressive action of the compressor with the thermal exchange (heat radiation) of the condenser.

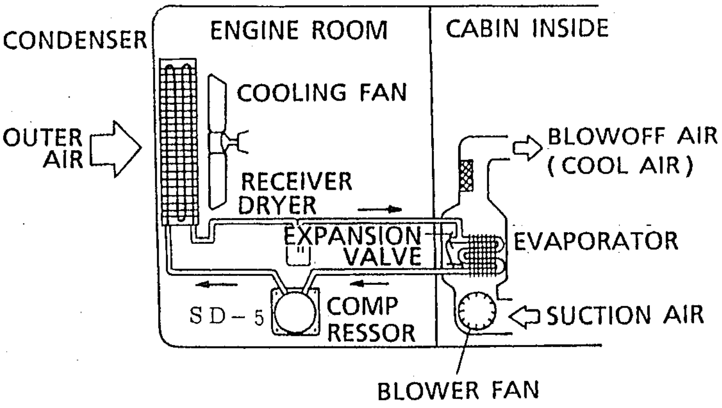


Fig. 6 Construction of refrigeration circuit

3.3 COMPONENT PARTS

(1) Evaporator (see fig. 7.)

The evaporator is a heat exchanger that plays an important role in absorbing heat from the objective air in the cabin by utilizing the latent evaporation heat of liquid coolant under low pressure and low temperature. Therefore, sufficient heat transfer must be performed between an object to be cooled and the coolant in the evaporator.

For this purpose, the evaporator is so constructed as to provide good heat transfer between coolant and air by the installation of fins on it's air intake side and by increasing the heat transfer area of the air intake side.

Moisture in the air is condensed as it is cooled and deposits on the outside of the evaporator in the form of water drops.If the water drops freeze, the cooling effect is deteriorated, and consideration of a means of draining out water is an important point.

The amount of coolant to be supplied to the evaporator is controlled by the expansion valve which will be mentioned in the following section. To make it perform appropriate control of the feed rate, it is necessary to decrease a pressure drop of the coolant in the evaporator. For this reason, reduction in the pressure drop becomes an element that contributes to the full attainment of the performances of the evaporator.

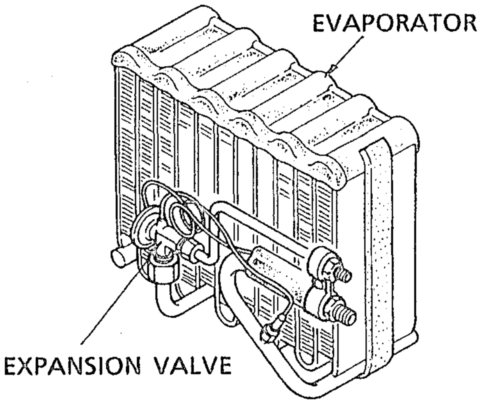


Fig. 7 Evaporator

(2) Expansion valve

In order to enable the evaporator to display it's full performances, a proper amount of low pressure, low temperature liquid-state coolant must be supplied to the evaporator. If the supply is too short, the coolant evaporates early in the evaporator and deteriorates the cooling effect. If the supply is too much, unevaporated liquid-state coolant returns to the compressor (liquid back), which results in degradation of the cooling effect and damage to the compressor valves.The expansion valve serves to supply liquid coolant running in at high pressure and high temperature to the evaporator as low pressure, low temperature liquid coolant (incompletely dried wet steam) and at the same time controls the feed rate of the coolant.Fig. 8 illustrates the construction of a thermo sensing expansion valve with a built-in pressure equalizer. The pressure sensing tube in this figure is installed on the outlet tube of the evaporator and indirectly senses the temperature of the coolant at the outlet of the evaporator. Usually saturated R-12 is sealed in the temperature sensing tube and the conduit.The pressure of R-12 changes as temperature being sensed varies. These pressure changes are turned to variations in the force acting upon the diaphragm. The high pressure, high temperature liquid coolant running in from the receiver side reduces it's pressure sharply as it passes through the valve. Part of the coolant evaporates by it's own heat and gets cooled off. It is then supplied to the evaporator as low pressure, low temperature moist vapor-state coolant. The opening of the valve is determined by balance between the pressure (low pressure) on the evaporator side, the action of the adjust spring and the force pressing the diaphragm (the tem-perature of the coolant at the outlet of the evaporator that the temperature-sensing tube senses.). The valve is so designed as to automatically control the feed rate of the coolant so that properly superheated coolant (3-8deg) gets out of the evaporator under the pressure in the evaporator.

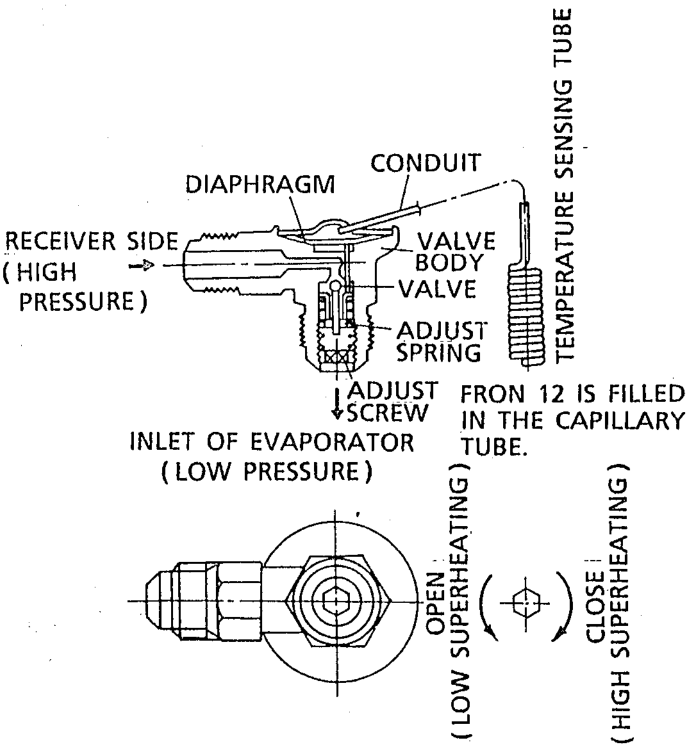

TEMPERATURE SENSING TUBE
CONDUIT
DIAPHRAGM
RECEIVER SIDE
(HIGH PRESSURE)
VALVE BODY
VALVE
ADJUST SPRING
ADJUST SCREW
FRON 12 IS FILLED IN THE CAPILLARY TUBE.
INLET OF EVAPORATOR
(LOW PRESSURE)
OPEN
(LOW SUPERHEATING)
CLOSE
(HIGH SUPERHEATING)

Fig. 8 Expansion valve

This action serves to control the feed rate of the coolant as the coolant temperature at the outlet of the evaporator is sensed as against the pressure at the inlet of the evaporator. As the result, excessive pressure drop of the coolant in the evaporator makes the control of superheating or the control of the feed rate of the coolant difficult. For this reason, low pressure drop in the evaporator is desirable. It is the temperature sensing expansion valve with an outer pressure equalizer that senses the pressure and the temperature of the evaporator and controls the superheating of the feed rate of the coolant to the evaporator properly. The air conditioner of this machine employs such an expansion valve with an outer pressure equalizer.

(3) Compressor (see fig.10.)

The compressor performs the following three functions in the cooling circuit.

1) Suction action
2) Pumping action
3) Compressive action

1) The suction action, as combined with the throttling action of the expansion valve, serves to lower the pressure of the coolant in the evaporator. This permits the coolant to be evaporated at low temperature so that cooling is performed effectively.

2) The pumping action serves to circulate the coolant in the cooling circuit. This permits continuous cooling.

3) The compressive action, as combined with a condenser mentioned below, works to bring evaporated coolant back to a liquid state.

Saturation temperature rises as pressure rises. For instance, it becomes possible to cool and liquefy coolant, using outside air of 35°C (95F°). The compressive action of the compressor works to convert low-pressure vapor-state coolant to high-pressure vapor-state coolant so that next condenser cools the coolant. Since the compressive action is performed in a short time, the coolant does not exchange heat with outside air. That is to say, it takes on a kind of adiabatic compression, so that the coolant discharged out of the compressor changes into high-temperature, high-pressure vapor and is delivered to the condenser.

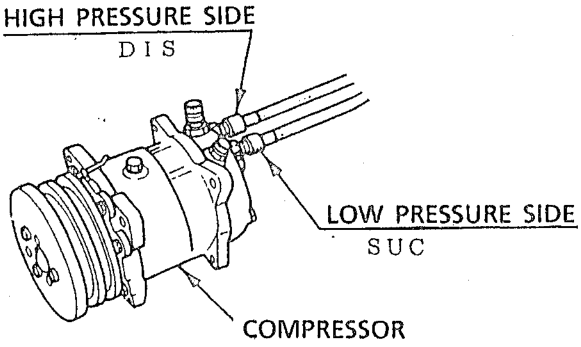


Fig. 10

(4) Condenser (see fig.11.)

This is a heat exchanger that cools and condenses high-temperature, high-pressure vapor-state coolant by outer air. Contrary to the case with the evaporator, heat transfers from coolant to air. A fan is installed also to improve heat transfer on the air side. If cooling by the condenser is not enough, the evaporator is unable to cool the air in the compartment sufficiently. Therefore, ventilation required for the cooling of coolant must be provided.

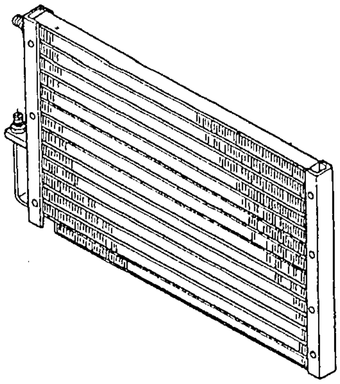


Fig. 11 Condenser

(5) Receiver dryer (see fig.12.)

1) Receiver tank

In an air-conditioner, the revolution of the compressor varies greatly which causes an appropriate amount of coolant for the cooling circuit to vary. The receiver tank receives such variations, stores temporarily extra coolant when the cooling circuit does not require much coolant and supplies coolant to the cooling circuit when a lot of coolant is needed. Furthermore, the receiver tank serves to store surplus coolant to supplement minimal leakage of coolant due to penetration through rubber hoses.

2) Dryer

If water is mixed in the cooling circuit, such disturbances as deterioration of valves and oil, corrosion of metal composing the circuit and clogging of the circuit due to freezing in the expansion valve may occur. In the cooling circuit, it is said to be desirable to hold down the density of water mixed in coolant below 30ppm. Use mo-lecular sieve as desiccant suited to the circuit of the air conditioner so as to absorb moisture intruding into the circuit at in-stallation and when filling coolant.

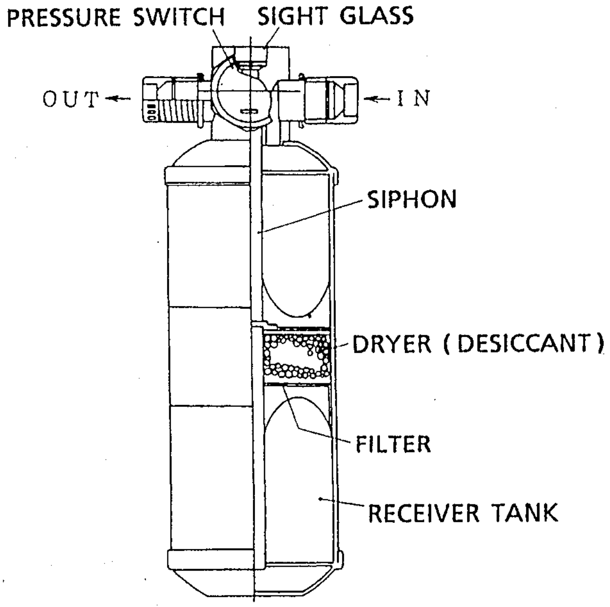


Fig. 12 Receiver dryer

3) Sight glass

This is a peep window used to determine the amount of coolant in the circuit. This is an only place through which the circuit interior can be confirmed visually.

4) Filter

5) Pressure switch

High / low pressure type pressure switches are employed in this air conditioner. When pressure rises abnormally (more than 27kgf/cm^2) (384 psi), it cuts off the power supply to the compressor to protect the circuit. When the pressure of the circuit falls below 2.1kgf/cm^2 (29.9psi) because of gas leakage, etc., it cuts off the power to the compressor to detect leakage of coolant.

4. DISASSEMBLY AND ASSEMBLY

4.1 PRECAUTIONS ON OPERATION

(1) Tightening torque (see table 2.)

1) Pipe joint
When connection a pipe joint, coat o ring and the thread with refrigerator oil (Susoni 5GS) and tighten the joint by means of an offset wrench.

2) Screws and bolts (see table 3.)
Tighten screws and bolts to the tightening torques specified in table3.

(2) Amount of oil in the compressor (see table 4.)
207cc (12.6 cuin) of oil is filled in the SD compressor (HD type). Shortage of oil develops seizure at high speed and degrades the durability of the compressor. Inversely, excess of oil deteriorates the cooling performances.Once the air-conditioner operates, part of the oil is distributed in the cooling cycle. Adjust the oil volume according to table 4 if you replace the parts in table 4.

(3) To perform operation, stop the engine and turn the power of the air-conditioner off.

(4) After completion of operation, confirm that faults have been remedied completely by running the air-conditioner.

Table 2.

Tightening part of piping	Tightening torque (kgf-cm) (ft·lbs)
D hose and compressor	200~250 (14.4~18.0)
D hose and condenser	200~250 (14.4~18.0)
L hose and condenser	120~150 (8.67~10.8)
L hose and receiver dryer	120~150 (8.67~10.8)
L hose and air-conditioner unit	120~150 (8.67~10.8)
S hose and air-conditioner unit	300~350 (21.7~25.3)
S hose and compressor	300~350 (21.7~25.3)
Evoporator inlet pipe and expansion valve	120~150 (8.67~10.8)
Expansion valve and evaporator	200~250 (14.4~18)
Pressure sensing part on ex-pansion valve and e-vapora-tor outlet pipe	100~160 (7.22~11.6)

Table 3.

Nominal dia (mm) (in)	Tightefning torque (kgf-cm) (ft·lbs)
4 (0.1575)	10-20 (0.7-1.4)
5 (0.1969)	20-30 (1.4-2.2)
M6screw (attached to condenser)	40-50 (2.9-3.6)
6 (0.2362)	40-60 (2.9-4.3)
8 (0.3150)	100-160 (7.2-11.5)

Table 4.

Part to be replaced	Amount of oil to be adjusted
Compressor	① Measure the amount of oil in removed compressor. ② 207cc(12.6cuin)-(amount of oil in (1)+30cc ((1.83cuin)) = amount of oil remaining circuit. ③ Discharge the amount of oil equaling the volume left in a new compressor and install the compressor.
Air-conditioner unit	Replenish 15cc (0.92cuin)
Receiver dryer	Replenish 20cc (1.22cuin)
Condenser	Replenish 20cc (1.22cuin)

☞ Use Suniso 5GS to replenish oil.

4.2 ATTACHING AND DETACHING THE UNIT CASING (SEE FIG.13.)

The numbers in parentheses after part names match the numbers in the construction drawings.

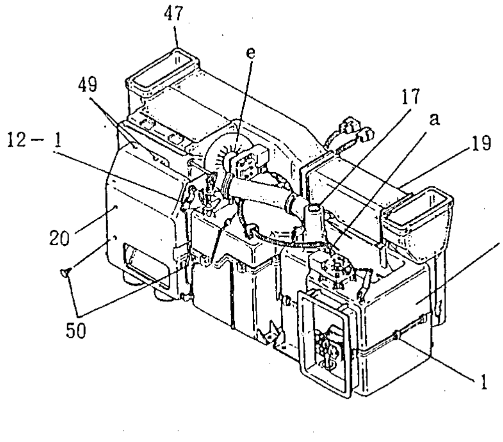
(1) Removing the intake unit

1) Remove two T4 tapping screws (49) and four T5 tapping screws (50). Then remove duct retainer (47) and upper duct (19).

2) Draw up cool-and -hot box duct (17).

3) Separate the coupler (a) intake.

4) Take off ten clamps (1) and remove fan case upper (6).



As seen from the front

(2) Disamantling the air-conditioner unit

1) Remove upper duct (19) the same way as above.

2) Remove intake harness (15) from cord fastener (14).

3) Take off air mix actuator coupler (C), four M4 screws (d), motor actuator (28) and thermister coupler (e).

4) Separate rod (35) from rod holder sections A, B (12-1) (12-2).

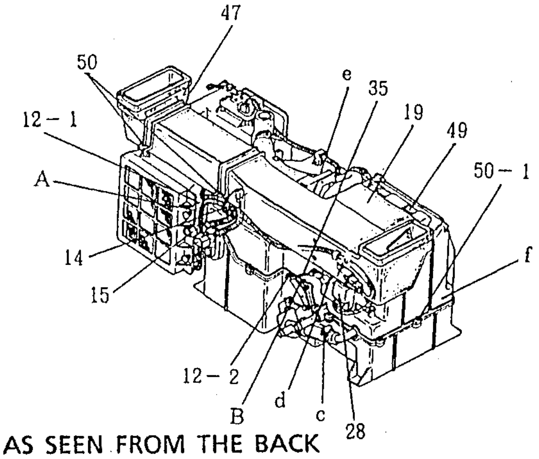
5) Remove two T4 tapping screws (49), two T5 tapping screws (50) and lower duct (20).

6) Remove fifteen T5 tapping screws (50-1) and then casing upper (f).

(3) Mounting

Perform mounting in the reverse order of dismantling.

☞ Exercise care so that the thermister cord may not be pinched in the casing.



AS SEEN FROM THE BACK

Fig. 13 Dismantling the unit casing

4.3 REPLACING THE BLOWER MOTOR (SEE FIG. 14.)

(1) Dismantling

1) Dismantle the intake unit casing, referring to 4.2 (1) above.

2) remove two M6 washer-attached bolts (22) and dismantle motor retainer (10).

3) Separate motor cushion (7) from the drum of motor (12-1).

(2) Mounting

Mount the motor in the reverse order of dismantling. watching the following instructions.

1) Place the motor so casing (a) come in contact with section A of the motor. At that time, confirm that the clearance between fan (12-2) and both sides of casing(e) is more than 2mm. (0.08")

2) Attach cord (12-3) of the motor so it lies in the position of fig.C.

3) Match the hole (b) in the blower motor body to the hole (d) in the motor cushion.

4) Do not dismantle fan (12-2) from blower motor (12-1).

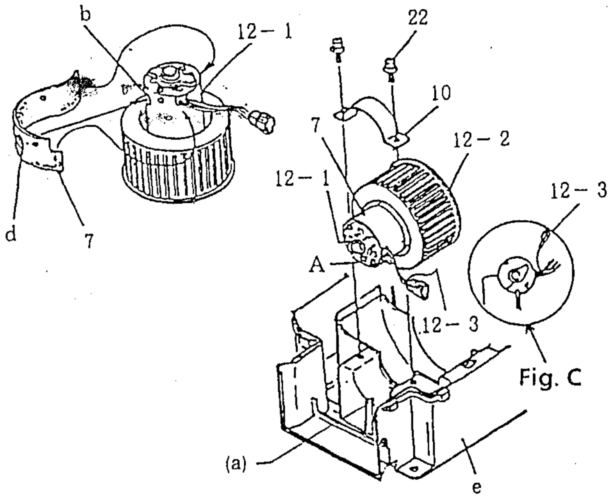


Fig. 14 Replacing the blower motor

4.4 REPLACING THE THERMISTER (SEE FIG. 15.)

(1) Dismantling

1) Dismantle the air-conditioner unit casing, referring to 4.2 (2) above.

2) Disconnect the cord of thermister (5) from the groove (a) of casing (b).

3) Draw out sensor holder(13) from evaporator (15).

4) Take off thermister (5) from sensor holder (13).

(2) Mounting

Mount the thermister in the reverse order of dismantling, referring to the following instructions.

1) When installing thermister(5) to sensor holder (13), do it so only the sensor (5-1) stands above the surface as shown in the illustration. Take care also so that air mix damper(45) does not interfere with other sections.

2) Exercise care so the cord of thermister (5) is not pinched in the casing (b).

4.5 REPLACING THE EVAPORATOR AND THE EXPANSION VALVE (SEE FIG.16 AND FIG.17)

(1) Dismantling expansion valve (4)

1) Dismantle the air-conditioner unit casing, referring to 4.2 (2) above.

2) As shown in Fig.16, dismantle evaporator (15) and expansion valve (4) in an as-assembled condition from the casing.

3) Peel off thermo-sensing insulating material (1) and dismantle thermo-sensing tube stay(10). (See Fig.17.)

4) Loosen nuts (a) (b) (c) and then disconnect pipes.

(2) Dismantling the evaporator (15)

1) Perform the items 1-4 above.

2) Take off screws (58) and separate retainer (57).

(2) Mounting

Mount the evaporator in the reverse order of dismantling, referring to the following instructions.

1) Mount thermo-sensing tube (d) as shown in the cross-sectional view.

2) Coil extra length of capillary tube (4-1) in a diameter of about 20mm (0.8in) beforehand.

3) When installing the expansion valve ass'y to the casing, place it so retainer (27) is fixed to the casing.

4) Since heat insulation material is not re-usable, replace it at the same time that expansion valve(4) is replaced. Adhere both sides of insulation material together so the thermosensing part is separated from the outside air.

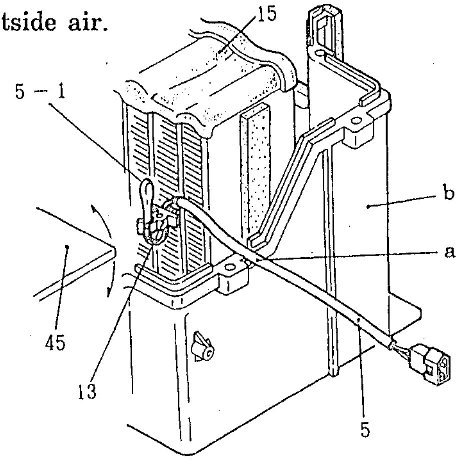


Fig. 15 Replacing the thermister

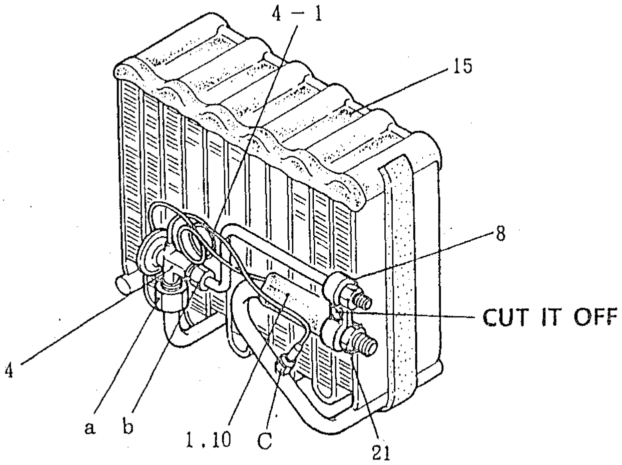


Fig. 16 Evaporator-expansion ass'y

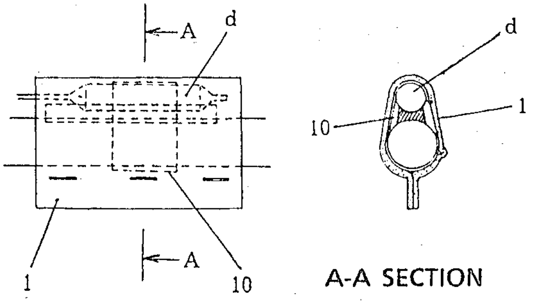


Fig. 17 Thermo-sensing part

4.6 REPLACING THE INTAKE DAMPER ACTUATOR (SEE FIG.18.)

(1) Dismantling

1) Release rod clamp (2) and remove rod (16).

2) Remove the connector of harness (15) and four tapping screws (20). Then dismantle motor actuator (13).

(2) Mounting

1) Install motor actuator (13) with tapping screws (20) and then fit the connector.

2) Turn damper lever (17) in the direction of the arrow, and when it stops, press it lightly. In that condition, fix rod (16) with rod clamp (2).

☞ Never take off the rod clamp on occasions other than when replacing the motor actuator. When it is removed, turn the fan switch "ON" to introduce outside air. Then fix the rod according to the above procedure.

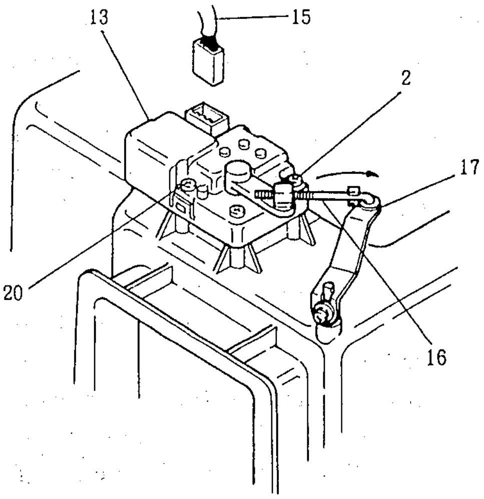


Fig. 18 Actuator section of intake damper

4.7 REPLACING THE WATER VALVE, AIR MIX LINK AND ACTUATOR (SEE FIG. 19.)

(1) Cautions to be taken when replacing water valve (30)

1) Turn the fan switch "ON", set the temperature control to COOL MAX (Only one LED on the control panel lights.) and then dismantle the water valve (30).

2) Attach valve rod (c) to rod clamp (30-1), turn lever (30-2) in the direction of (b) so spring (30-3) deflects about 1mm (0.04in) and then attach valve rod (33) to rod clamp (B).

3) Replace heater hose (26) together.

(2) Cautions to be taken when replacing motor actuator (28)

1) Remove rod clamp (A) and tapping screw (D) and then dismantle motor actuator (28).

2) Turn damper lever (38) in the direction of the arrow (a) and attach rod (35) to rod clamp (A), while pressing the damper lever.

3) Perform necessary adjustment after replacement of the motor actuator in 4.9.

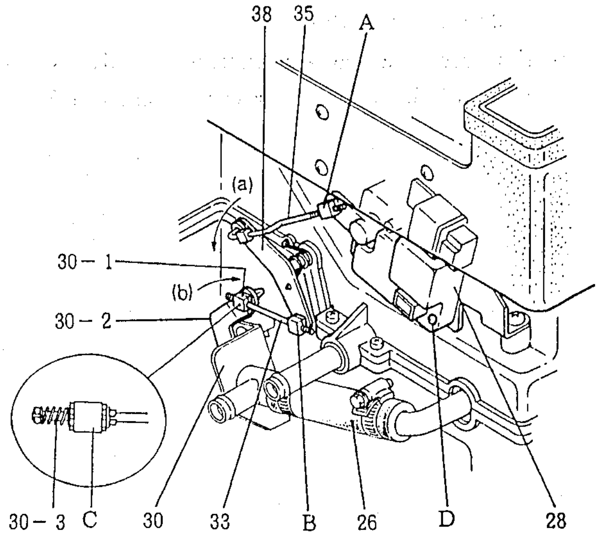


Fig. 19 Water valve and air mix link actuator

4.8 REPLACING THE MODE DAMPER LINK AND ACTUATOR (SEE FIG.20.)

(1) Cautions to be taken when replacing links

1) When replacing links (except motor actuator (29)), turn the fan switch "ON" and direct the blowout direction upward.

2) At last, fix rod clamps (a) (b) according to the following steps.

   i. Rotate link A (34-3) of mode link ass'y (34) so it comes to the position in fig.20. (The mode damper closes the blowout opening.)

   ii. Turn deflection damper (41) in the direction of (A), press it lightly from the position at which it stops and attach deflection link rod (37) to rod clamp (b).

   iii. Attach mode link rod (36) to rod clamo (a). pulling it in the direction of (B).

(2) Cautions to be taken when replacing the motor actuator

1) Rotate link A (34-3) the same way as item 2. above to the position in fig.20 and replace motor actuator (29).

2) Perform necessary adjustments after replacement of the motor actuator in para. 4.9.

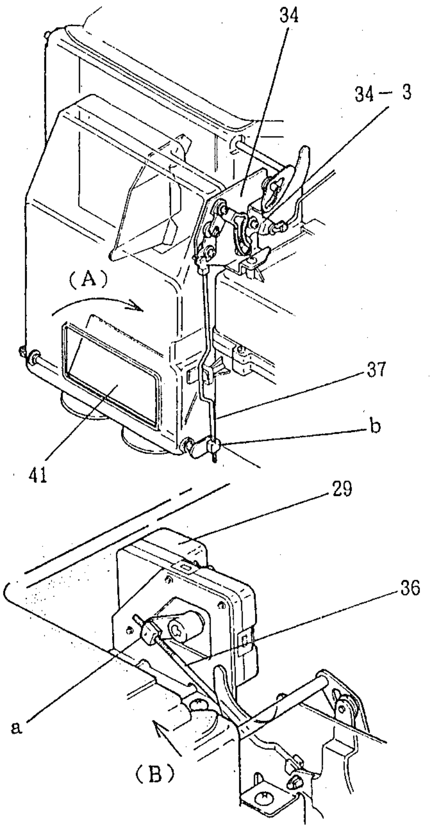


Fig. 20 Mode damper links and actuator section

4.9 ADJUSTMENTS AFTER REPLACEMENT OF MOTOR ACTUATOR

When the motor actuator has been replaced, do not fail to make adjustments according the instruction manual plastered on the control amplifier. Adjustments are not needed when you replace the intake actuator. (See fig.21.)

☞ If no air blows out of the lower blowout opening in position of the mode select LED on the instrument panel even after adjustments have been made according to the instruction manual, turn VR(M) clockwise a little. If no air blows out of the upper blowout opening by this adjustment, turn it counter-clockwise. (See fig.22.)

VR (M)………… Mode actuator adjust volume
VR (T) ………… Air mix actuator adjust volume

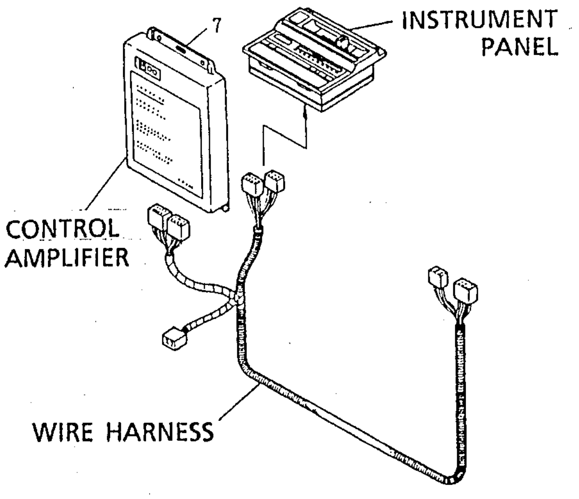


Fig. 21

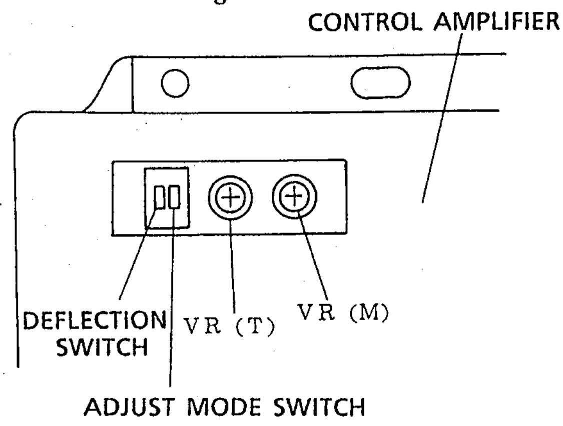


Fig. 22

4.10 REPLACING THE RESISTOR

(1) Dismantling

1) Remove the intake unit casing, referring to para. 4.2.
2) Take off connector (14-1) and then tapping screw (21.) Then remove resister cover (9).
3) Separate the cord from cord clamp (5). Take off two tapping screws (24) and separate resistor (14) from resistor cover (9).

(2) Mounting

Mount the resistor in the reverse order of dismantling, according to the cautions given below.

1) Do not draw out intake harness (15) longer than necessary. Fix the cord of resistor (14) by means of cord clamp (5) and confirm that it does not interfere with the deflection damper.
2) Note that if foreign matter enters resistor cover (9), it may be ignited.

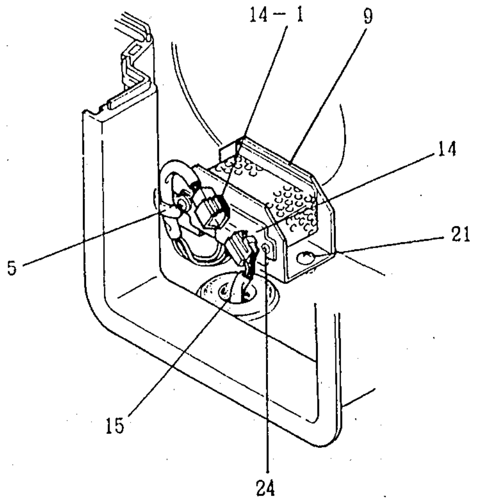


Fig. 23 Resistor section

5. METHOD OF FILLING UP COOLANT

5.1 CAUTIONS ON OPERATION

(1) Always have a designated person do charge operation. Since coolant uses high pressure gas involving dangers in charging operation, always have a designate person familiar with operation perform charging operation.

⚠

- always wear protective goggles. (You may lose your sight if coolant enters your eyes.)
- Liquid-state coolant is at very low temperature [about -30°C (-22°F)], handle it with due care. (Your skin may be frostbitten.)
- Coolant (fron-12) is harmless in that condition, but on contact with high temperature [about 400°C (752°F) or over], it dissolves to produce harmful substance (carbonyl chloride gas, etc.). Therefore, never release coolant in a room of poor ventilation where there is a source of fire.

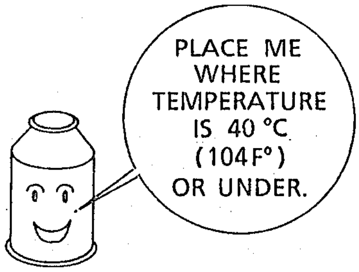

PLACE ME WHERE TEMPERATURE IS 40 °C (104F°) OR UNDER.

Fig. 24

(2) Storage and transportation

1) Keep a service can (hereinafter called "can") at a temperature of 40°C (104°F) or under. Since high pressure gas R-12 is filled in a can in a saturated liquid state, the pressure in the can rises sharply as temperature rises, posing dangers of explosion. Therefore, the temper-ature of the can must be held below 40°C (104°F). (See fig.24.)

2) For storage of cans, avoid an area exposed to direct sunlight and choose a cool dark place.

3) If coolant is placed near a fire, the temperature rises as affected by radiation heat. This raises the pressure inside the can, increasing dangers of explosion. Therefore, do not bring coolant near a fire in any circumstances. (See fig.25)

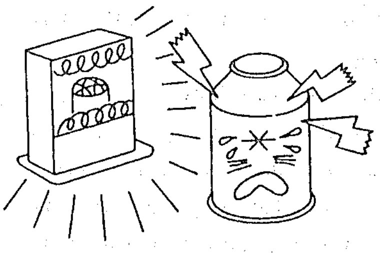


Fig. 25

4) If radiation heat of sunlight enters a closed compartment, it raises the inside temperature very much and in areas exposed to direct sunlight, the temperature may, in some cases, rises to dangerous levels even in the wintertime, Also keep in mind that the temperature rises to dangerous levels even in the trunk room in the summertime. (See fig.26.)

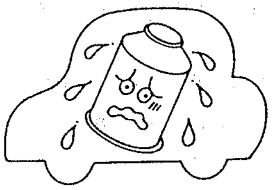


Fig. 26

5) Note that the can gets weak if flaws, blow marks and distortion are present on the can. (See fig.27.)

   1. Take care so as not to drop or knock the can.
   2. Do not throw or drop the can and a package of cans during transportation, loading and unloading.

6) Store cans out of reach of children.

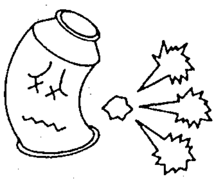


Fig. 27

(3) At charge operation

1) To warm the can for charging, always open the service can valve and the low pressure valve of the gauge manifold and warm the can in water of 40°C (104°F) or below. (Temperature at which you do not feel hot when you put your hand in the water). If the can is put in hot water or heated by direct fire, the pressure rises quickly, increasing dangers of explosion. (See fig.28.)

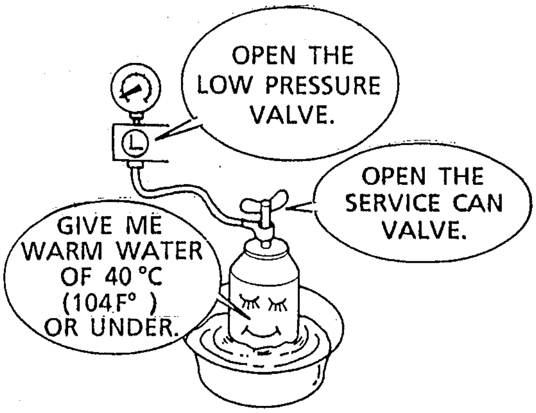

OPEN THE LOW PRESSURE VALVE.
OPEN THE SERVICE CAN VALVE.
GIVE ME WARM WATER OF 40 °C (104F°) OR UNDER.

Fig. 28

2) To charge coolant by starting the engine, do not open high pressure valve (HI) of the gauge manifold in any circumstances. Keep in mind that if the high pressure valve is opened, high pressure gas flows back and may explode the service can and the charging hose.

(4) Others

Never use service cans again as it is prohibited by law. Do not allow foreign matter to enter the air-conditioner circuit. The refrigeration cycle is affected by air, moisture and foreign matter. Install the component parts of the air-conditioner correctly and quickly and pay full attention to the intrusion of moisture and dirt.

⚠ Handle Flon gas with care to protect nature.

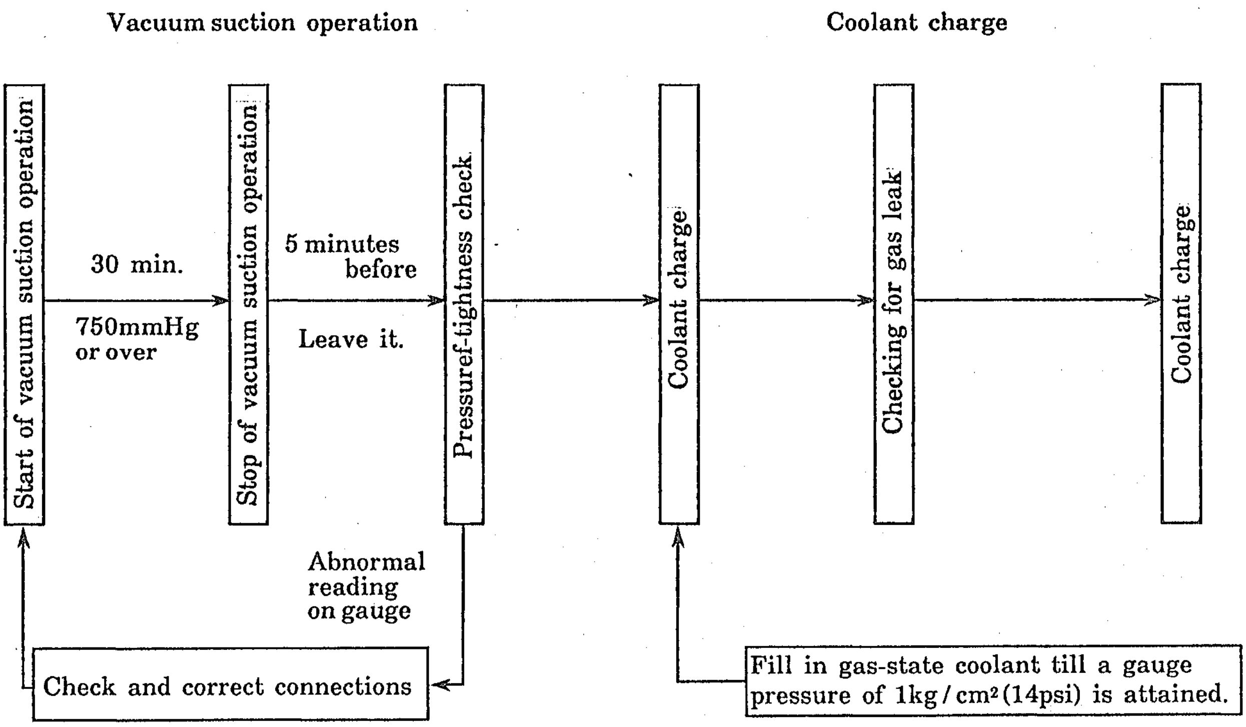
- Use care so as not to release the gas to atmosphere.
- Exercise care so as not to overcharge the gas.
- Tighten piping to specified torques.

5.2 OPERATION PROCEDURE

(1) Coolant charging into the air-conditioner consists of "Vacuum suction operation" and "gas charging operation".

1. "Vacuum suction operation" is an operation which eliminates moisture in the air-conditioner circuit. Even a negligible amount of moisture left in the circuit freezes in the orifice of the expansion valve during operation, thereby resulting in clogging of the circuit, rusting in the circuit and different kinds of faults. Therefore, before charging coolant into the circuit, vacuum suction operation is executed to boil and evaporate moisture in the circuit. This is the vacuum suction operation.
2. "Gas charging operation" is an operation in which coolant is charged into the circuit after vacuum suction operation. Gas charge not only affects the cooling performance of the air-conditioner, but also affects the service expectancy of sections that compose the circuit. Extreme overcharging makes the circuit pressure abnormally high and causes the cooling performance to deteriorate. On the contrary, undercharging deteriorates the circulation of lubricating oil through the compressor and causes seizure of the moving surface of the compressor. Since gas charging operation involves handling of high pressure gas, improper handling poses extreme dangers. Therefore, perform coolant charging operation in accordance with the instructions and cautions stipulated in this manual.

(2) Operation chart



Vacuum suction operation
Coolant charge
Start of vacuum suction operation
30 min.
750mmHg or over
Stop of vacuum suction operation
5 minutes before
Leave it.
Pressure-tightness check
Abnormal reading on gauge
Check and correct connections
Coolant charge
Checking for gas leak
Coolant charge
Fill in gas-state coolant till a gauge pressure of 1kg/cm² (14psi) is attained.

5.3 CHARGING PROCEDURE

1. Vacuum suction operation

(1) Connecting the gauge manifold (See fig.30.)

1) Close the high pressure valve (HI) and the low pressure valve (LO) on the gauge manifold.

2) Connect the charging hoses (red and yellow) to the service valve of the compressor.
Red hose : high pressure side (HI) of gauge manifold ⟶ high pressure side (DIS) of compressor.
Yellow hose : low pressure side (LO) of gauge manifold ⟶ low pressure side (SUC) of compressor

☞ ● Take care so as not to mistake the high pressure side for the low pressure side when connecting them together.
● Connect the tip (crooked like an L-letter) of the charging hose to the service valve of the compressor. The L-letter side of the hose has a rubber core fixed. If the hose is connected inversely, the core valve of the compressor opens. (See fig. 31.)

3) Connect the center valve of the gauge manifold with the charging hose of the vacuum pump.

☞ Some kinds of gauge manifolds have no open / close valve in the center.

(2) Vacuum suction (see Fig. 32)

1) Open the high-pressure valve (HI) and the low-pressure valve (LO) on the gauge manifold.

2) Turn on the vacuum pump switch and perform vacuum suction for about 30 minutes.

3) When vacuum suction for a specified time is over (vacuum degree :-750mgHg or under), close the high pressure valve and the low pressure valve of the gauge manifold.

4) Then, turn off the vacuum pump switch.

(3) Air-tightness check
Leave the high-pressure valve and the low-pressure of the gauge manifold closed for more than five minutes and confirm that the pointer of the gauge does not return toward zero.

☞ If the pointer of the gauge swings toward zero, it implies that there must be leakage somewhere. In that case, retighten pipe joints, perform vacuum suction once again and confirm that no leakage occurs.

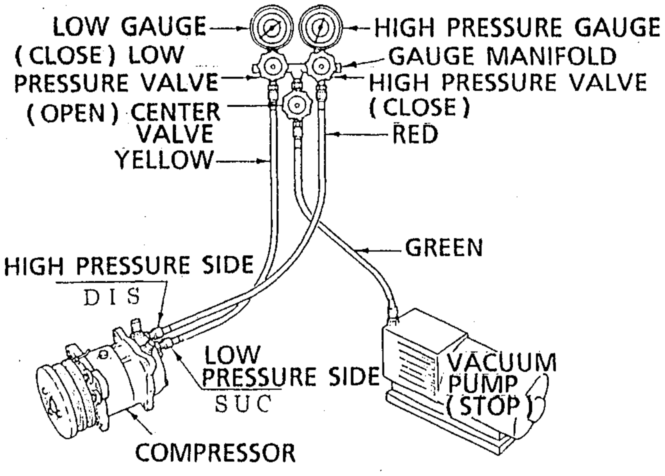

LOW GAUGE
HIGH PRESSURE GAUGE
(CLOSE) LOW PRESSURE VALVE
GAUGE MANIFOLD
HIGH PRESSURE VALVE (CLOSE)
(OPEN) CENTER VALVE
RED
YELLOW
GREEN
HIGH PRESSURE SIDE
DIS
LOW PRESSURE SIDE
SUC
VACUUM PUMP (STOP)
COMPRESSOR

Fig. 30 Gauge manifold connections

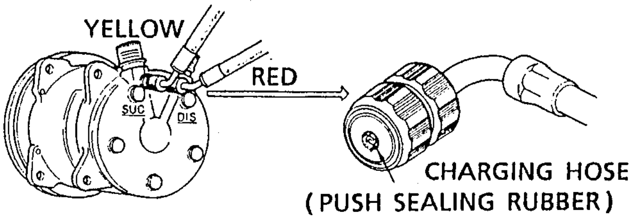

YELLOW
RED
SUC
DIS
CHARGING HOSE
(PUSH SEALING RUBBER)

Fig. 31 Connecting the compressor pipes

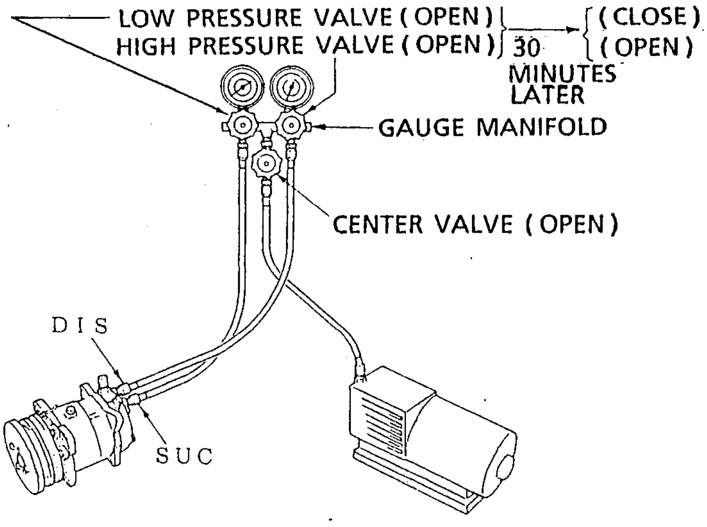

LOW PRESSURE VALVE (OPEN)
HIGH PRESSURE VALVE (OPEN)
30 MINUTES LATER
(CLOSE)
(OPEN)
GAUGE MANIFOLD
CENTER VALVE (OPEN)
DIS
SUC

Fig. 32

2. Gas charging operation

(1) Charging from high pressure side (see Fig. 33.)

1) After repeated vacuum suction operation, change the charging hose (green) of the gauge manifold from the vacuum pump to the service can.

2) Air purge
Open the valve on the service can. (However, keep the high-pressure and low-pressure valve of the gauge manifold closed.) Then push the core valve of the side service port on the low pressure side of the gauge manifold by means of a screwdriver to release the air in the charging hose by the coolant pressure. (See fig. 33.) (Stop it when a hissing sound is heard.)

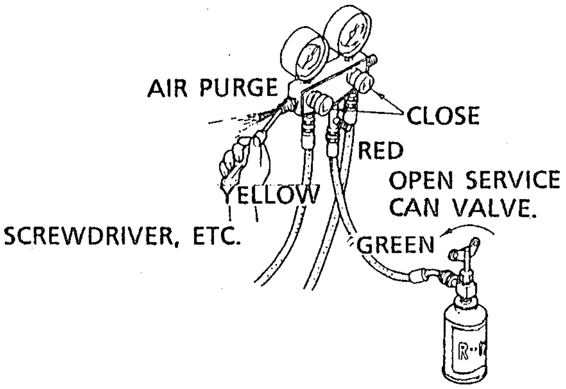

AIR PURGE
CLOSE
RED
OPEN SERVICE CAN VALVE.
YELLOW
SCREWDRIVER, ETC.
GREEN
R-1

Fig. 33 Gas charging operation

3) Open the high pressure valve of the gauge manifold and charge coolant. (Fill in coolant till the gauge pressure reaches 1kgf /cm^2 (14psi). After charging, close the high pressure valve of the gauge manifold and the valve on the service can.(See fig.34.)

⚠ Never run the compressor. (If coolant flows back, the service can and the hoses may be bursted, which is very dangerous.)

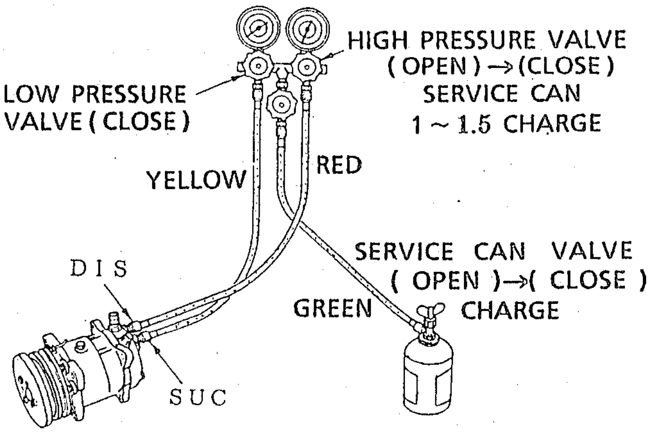

HIGH PRESSURE VALVE (OPEN) → (CLOSE)
SERVICE CAN 1 ~ 1.5 CHARGE
LOW PRESSURE VALVE (CLOSE)
YELLOW
RED
SERVICE CAN VALVE (OPEN)→(CLOSE) CHARGE
GREEN
D I S
S U C

Fig. 34 Gas charging operation (high pressure side)

(2) Check for gas leak
Check for gas leakage in the cycle carefully, using a leak detector. In case of any leakage, retighten loosened joints and correct leakage.

(3) Charging from low pressure side (see fig. 39.)

1) Confirm that the high pressure valve and the low pressure valve of the gauge manifold and the service can valve are closed.
2) Start the engine, increase revolution a little (medium speed) and fully open the cab door.
3) Turn on the air-conditioner switch. Turn the air flow select switch to maximum and turn the thermo switch to COOL max (coolest).
4) Open the low pressure valve of the gauge manifold and the service can valve. Then charge coolant till bubbles in the sight glass of the receiver disappear. (See fig.36.) (Total amount of gas charge : 1200-500g (2.65 lbs-1.10 lbs))
5) When coolant charging finishes, close the low pressure valve of the gauge manifold and the service can valve and stop the engine.

☞ ● Never open the high pressure valve on the gauge manifold.
● Do not turn over the service can in any case. (The compressor valve may be scored as coolant is sucked in a liquid state.)

(4) Checking the amount of charged coolant (see fig.37.)

Run the air-conditioner and increase the engine revolution. Compare the amount of bubbles seen through the sight glass. At this time, fully open the cab door, turn the air flow select switch to maximum and turn the thermo switch to Cool Max (coolest).

⚠ ● If the air-conditioner is run when coolant (R-12) is scarce, the compressor will be affected asversely.
● Overcharging of coolant results in under-cooling, to the contrary, increases the pressure in the circuit abnormally and develops dangers. Keep the amount of coolant to a proper level.

(5) Dismantling the gauge manifold

When inspection of coolant charge is over, dis-con-nect the charging hose from the compressor as follows.

1) Press the L-letter fitting of the low-pressure side charging hose (yellow)against the service valve of the compressor so coolant does not leak. Then loosen the nut. As soon as the nut comes off, remove the charging hose from the service valve
2) Leave the high pressure side till high pressure gauge reading falls (to 10kgf /cm²G or under (142 psi)).
3) Remove the high pressure side charge hose (red) the same way as for the low pressure side.

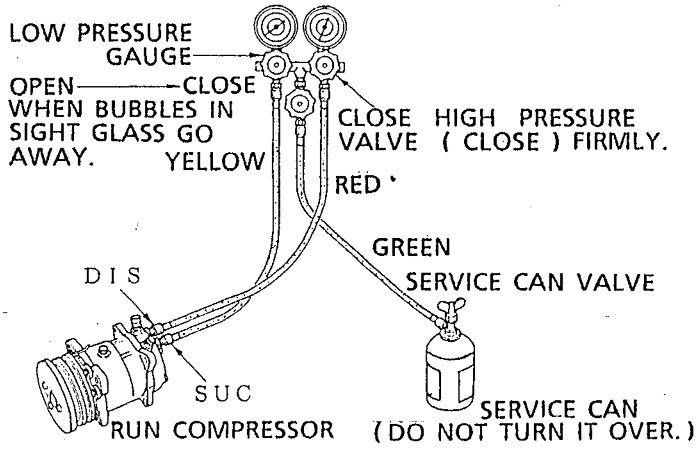

LOW PRESSURE GAUGE
OPEN——CLOSE
WHEN BUBBLES IN SIGHT GLASS GO AWAY.
YELLOW
CLOSE HIGH PRESSURE VALVE (CLOSE) FIRMLY.
RED
GREEN
SERVICE CAN VALVE
D I S
S U C
RUN COMPRESSOR
SERVICE CAN (DO NOT TURN IT OVER.)

Fig. 35 Gas charging operation (low pressure side)

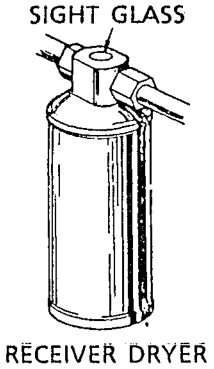


Fig. 36

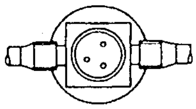
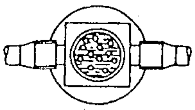
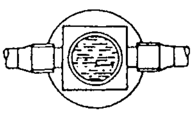
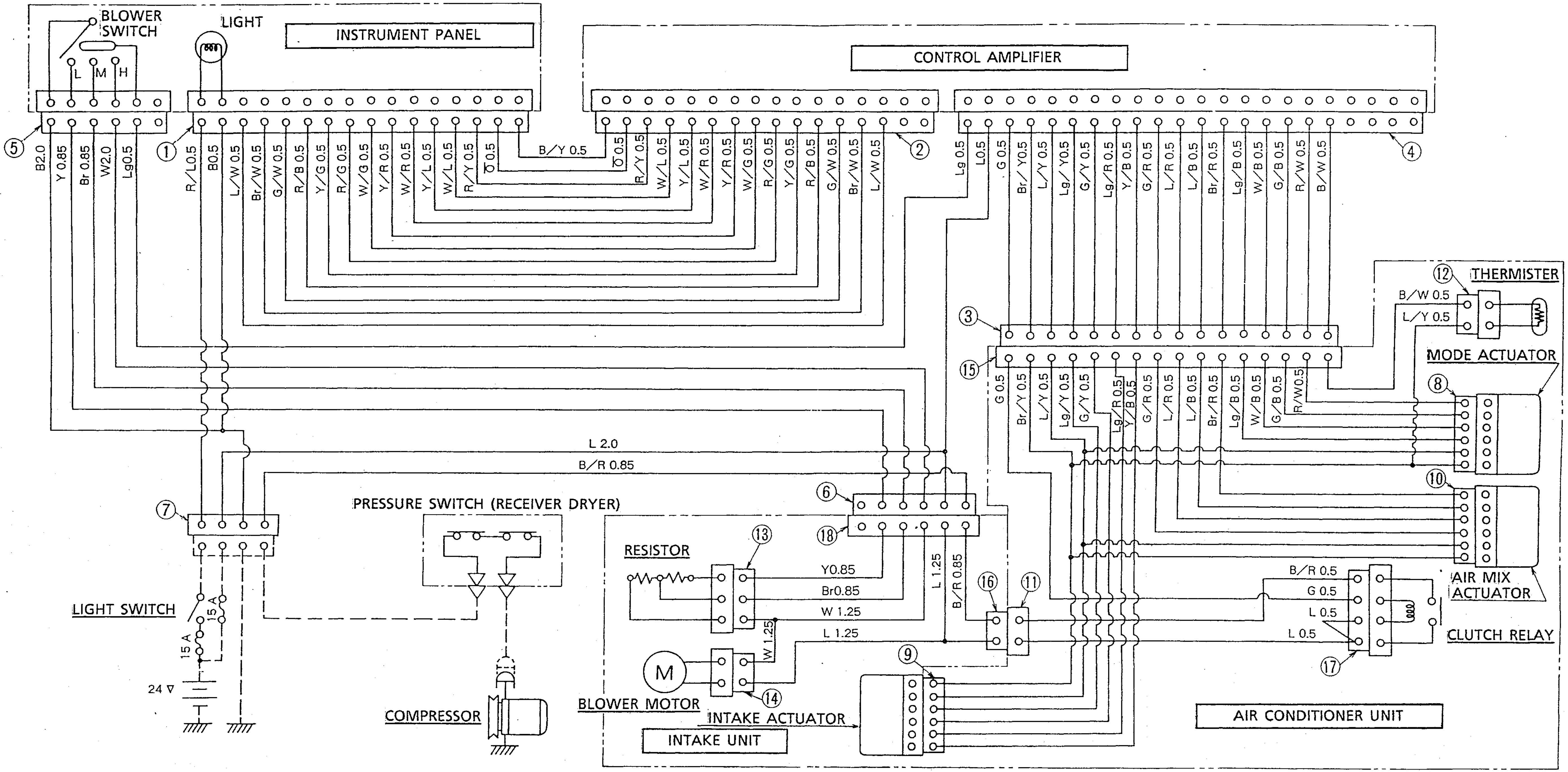
Amount of coolant	Sight glass condition
○ PROPER AMOUNT	 Nearly transparent. Although bubbles are seen, they became transparent as engine revolution is increased.
× SHORT	 Flow of bubbles can be seen.
× NEARLY INVISIBLE	 Fog-like things can barely be seen flowing.

Fig. 37

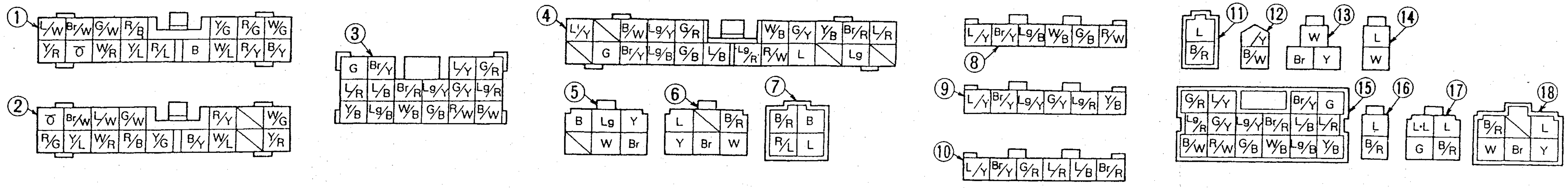
6. ELECTRIC CIRCUIT

6.1 ELECTRIC WIRING DIAGRAM


BLOWER SWITCH
L
M
H
LIGHT
INSTRUMENT PANEL
CONTROL AMPLIFIER
⑤
B2.0
Y 0.85
Br 0.85
W2.0
Lg0.5
①
R/L0.5
B0.5
L/W 0.5
Br/W 0.5
G/W 0.5
R/B 0.5
Y/G 0.5
R/G 0.5
W/G 0.5
Y/R 0.5
W/R 0.5
Y/L 0.5
W/L 0.5
R/Y 0.5
O 0.5
B/Y 0.5
②
O 0.5
R/Y 0.5
W/L 0.5
Y/L 0.5
W/R 0.5
Y/R 0.5
W/G 0.5
R/G 0.5
Y/G 0.5
R/B 0.5
G/W 0.5
Br/W 0.5
L/W 0.5
④
Lg 0.5
L0.5
G 0.5
Br/Y0.5
L/Y 0.5
Lg/Y0.5
G/Y 0.5
Lg/R 0.5
Y/B 0.5
G/R 0.5
L/R 0.5
L/B 0.5
Br/R 0.5
Lg/B 0.5
W/B 0.5
G/B 0.5
R/W 0.5
B/W 0.5
⑫
THERMISTER
B/W 0.5
L/Y 0.5
③
⑮
MODE ACTUATOR
⑧
⑩
L 2.0
B/R 0.85
⑥
⑱
PRESSURE SWITCH (RECEIVER DRYER)
⑦
LIGHT SWITCH
15 A
15 A
24 V
COMPRESSOR
RESISTOR
⑬
Y0.85
Br0.85
W 1.25
L 1.25
W 1.25
L 1.25
B/R 0.85
⑯
⑪
B/R 0.5
G 0.5
L 0.5
L 0.5
AIR MIX ACTUATOR
CLUTCH RELAY
⑰
⑨
M
BLOWER MOTOR
⑭
INTAKE ACTUATOR
INTAKE UNIT
AIR CONDITIONER UNIT

6.2 CONNECTOR DETAIL

Connector numbers match the numbers in the wiring connections.


①
L/W Br/W G/W R/B Y/G R/G W/G
Y/R O W/R Y/L R/L B W/L R/Y B/Y
②
O Br/W L/W G/W R/Y W/G
R/G Y/L W/R R/B Y/G B/Y W/L Y/R
③
G Br/Y L/Y G/R
L/R L/B Br/R Lg/Y G/Y Lg/R
Y/B Lg/B W/B G/B R/W B/W
④
L/Y B/W Lg/Y G/R W/B G/Y Y/B Br/R L/R
G Br/Y Lg/B G/B L/B Lg/R R/W L Lg
⑤
B Lg Y
W Br
⑥
L B/R
Y Br W
⑦
B/R B
R/L L
⑧
L/Y Br/Y Lg/B W/B G/B R/W
⑨
L/Y Br/Y Lg/Y G/Y Lg/R Y/B
⑩
L/Y Br/Y G/R L/R L/B Br/R
⑪
L
B/R
⑫
/Y
B/W
⑬
W
Br Y
⑭
L
W
⑮
G/R L/Y Br/Y G
Lg/R G/Y Lg/Y Br/R L/B L/R
B/W R/W G/B W/B Lg/B Y/B
⑯
L
B/R
⑰
L·L L
G B/R
⑱
B/R L
W Br Y

7. TROUBLSHOOTING

7.1 COOLING CIRCUIT

Symptom and result of diagnosis					Cause	Remedy
Poor cooling	Both high and low pressures are lower than specified.	Air bubbles are seen through sight glass.	Oil blots over piping and parts.		Gas leaks from pipe joints and parts.	Retighten or replace with new ones.
			No blotting of oil and gas reaction.		Natural leakage from hoses	Charge gas.
		No bubble are seen through sight glass.			Expansion valve is not adjusted properly. (Too much throttling)	Readjust or replace.
					Expansion valve clogged.	Eliminate clogging. Replace receiver or expansion valve.
					Lower pressure circuit evaporator is clogged.	Eliminate clogging or replace parts.
			Cooling does not work at high speed continuous run.		Expansion valve frozen. Moisture mixed.	After vacuum suction, charge coolant again. Replace receiver.
			Air flow lessens.		Air leaks from casing.	Plug with plastic tape or packing medium.
	Low pressure is higher than specified.	Air bubbles are seen through sight glass.	Compressor cylinder does not get hot. (Liquid pack)		Thermo - sensing tube of expansion valve is in poor contact.	Improve contact. Replace thermo-sensing tube stay.
					Expansion valve adjusted poorly. (Too much opened)	Readjust or replace.
		High pressure is lower than specified.	Compressor cylinder gets extremely hot. Objectionable odor is emitted.		Compression does not discharge sufficiently.	Repair.
		Hot air comes out of heater unit.			Water cock is adjusted incorrectly. Cock is faulty.	Confirm and readjust. Replace.
					Tightness of air damper is faulty. (Outer air introducing type)	Replace.
	High pressure is higher than specified.	Air bubbles are seen through sight glass.	Low pressure is lower than specified.		High pressure line before receiver is clogged.	Eliminate clogging or replace parts.
		Condenser is dirty or clogged.				Wash down condenser.
		Air bubbles are hard to go out even if water is poured over condenser. Receiver temperature is low.			Overcharging of coolant	Drain out coolant to a proper level.
					Air is contained.	Recharge coolant after vacuum suction. Replace receiver.
	Cooling does not work at high speed continuous run.	Frosting	Thermister is not cooled.		Thrmister position is incorrect.	Correct thermister position.
					Air leaks from casing.	Plug up with plastic tape or packing medium.
			Thermister is cooled.		Thermo sensor is faulty. (It is not turned off.)	Thermister cord id disconnected.
					Even if functions and performances are normal, frosting occurs occasionally if air-conditioner is run for a long time with air flow turned to M or L.	Keep the user well informed about usage. Increase air flow.

Symptom and result of diagnosis			Cause	Remedy
Noise	Compartment	Blower motor section.	Interference with fan casing. Intrusion of foreign matter into casing.	Eliminate foreign matter. Adjust fan motor position.
			Sound from brush. Interference with metal and thrust washer.	Sound comes out to some extent. Replace if sound is large.
		Gas sound (resembling a roaring sound).	Vibrating sound of gas (sound produced as gas is discharged and sucked by compressor).	No problem as to performance.
		Expansion valve section. Whistling sound, gas flowing sound.	Abnormal sound from faulty expansion valve. Expansion valve is normal.	Replace expansion valve if whistling sound is heard. Gas flowing sound occurs to some extent.
	Engine room	A sound that occurs when clutch is off.	Clutch bearing or idle pulley bearing is faulty.	Replace.
			Interference with clutch armature, loosened belt or screws.	Repair or replace clutch. Retighten screws.
		A sound comes out when compressor turns.	Compressor sound is faulty.	Repair or replace if compressor is faulty.
			Swing by loosened V-belt or loosened screws.	Tension belt. Retighten screws.
Others		Water leak, scattering of water.	Heater core or hose is broken.	Replace.
			Casing drain port or drain hose is clogged.	Clean.
		Unpleasant odor.	Cigarette smoke, dust and odor in the compartment stick to the fins and stay.	Wash evaporator. If humidity is high, open the door, and run air-conditioner for more than ten minutes with air flow set to L and revolution set to 1500rpm.

7.2 ELECTRIC SYSTEM

Thorough understanding of the electric circuits is essential for fault diagnosis of the electric system. Then you must be familiar with electric wiring to an extent that what circuit is wired to what part of an actual vehicle. If you get familiar with it, you will find the electric system divided into three trains. If a failure in some electric line of the air-conditioner occurs, you do not fail to locate the cause by checking from the troubled point to the power supply in correct sequence. In case you can not locate the cause, it means that you have missed checking something. You must suspect even a single cord. The table below lists up basic procedures of how faults should be diagnosed. Always check it with the electric wiring of an applicable model when using it.

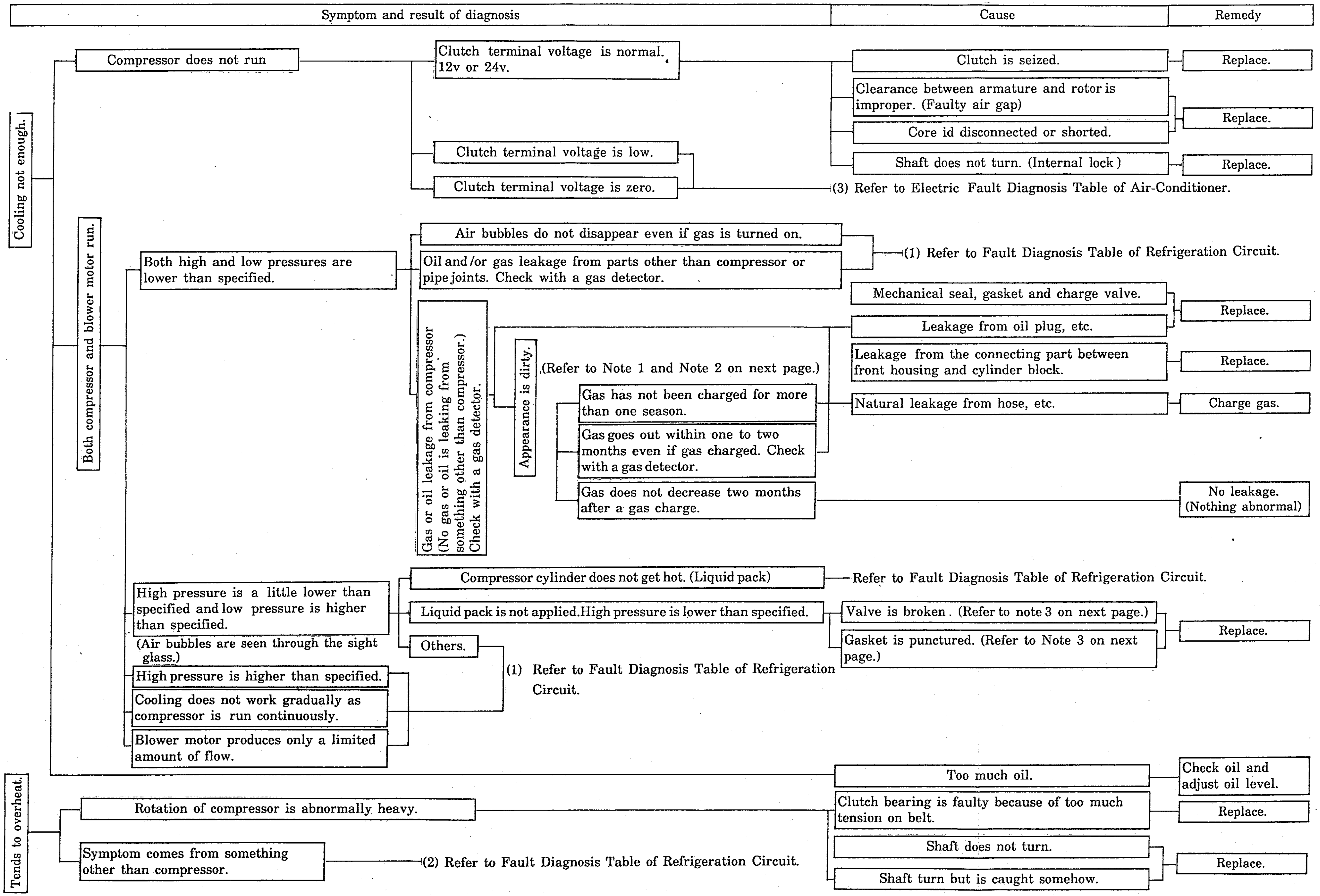
Symptom	Checking and judgment				Cause	Remedy
Neither clutch nor blower works.	Check fuses.	No fuse is blown.				To item (2)and (3).
		A fuse is blown.			Clutch and blower circuits are shortcircuited. (Power incoming end is improper.)	Repair. Do as instructed.
Only clutch does not perform suction.	Connect battery direct to clutch terminals.	No suction occurs.			Clutch is faulty.	Repair.
		Suction occurs.	Direct connect only thermo switch (relay) and clutch lines.	Clutch sucks.	Functional parts are faulty. (Control amplifier and receiver dryer)	fault diagnosis table of electronic thermostat
				Clutch does not suck.	Cord in clutch line is disconnected.	Repair.
Only blower does not run.	Connect battery direct to the plug terminal of blower motor.	It does not rotate.			Blower motor is faulty.	Replace.
		It rotates.	Connect select switch's L,M and H terminals to terminal B.	Rotates.	Selector switch is faulty.	Replace.
				Does not rotate.	Cord in blower line is disconnected.	Replace.
					Resistor is faulty.	Replace.
● Temperature control is out of order. ●Inside and outside air can not be changed over. ●Blowout mode can not be changed over.	Are not LED's on control panes flickering?	Do not flicker.	Check functioning of motor actuators.		Motor actuator does not work or is broken.	Replace.
				Operates.	Part of link and damper or water valve is faulty.	Replace or repair.
					Poorly adjusted.	Adjust.
		Flicker.	Check faulty points according to instructions plastered on the control amplifier.			Replace or repair.

7.3 ELECTRONIC THERMOSTAT

Symptom	Cause	Checking and judgment			Remedy
Clutch remains on.	Thermister is shortcircuited.	Measure resistance of thermister connector with a circuit tester.	Resistance is small.		Replace thermister.
			(Normal if resistance is about 2kΩ at (25°C (77°F)).)		
	Relay contacts are faulty or amplifier is faulty.	Remove thermister connector.	Is not deactuated.		Replace amplifier or relay.
Clutch remains off.	Thermister is faulty.	Measure resistance of themister connector with a circuit tester.	Resistance above 7kΩ.		Replace thermister and check amplifier.
	Thermo switch is faulty. (Or thermo volume harness is faulty.)	Turn switch on and measure resistance with a circuit tester. (Conductivity check)	Normal if resistance is 0.		
			Faulty if resistance is.		Replace control panel.
	Relay contacts are faulty or amplifier is faulty.	Disconect thermister and short the connector on the amplifier side.	Is not turned on.		Replace amplifier or relay.
Clutch chatters.	Contact condition of thermo switch is faulty.	Check conductivity on switch terminals in control panel, using a circuit tester. (Conductivity check)	The needle of a circuit tester moves when control panel is knocked on.		Replace control panel.
			Normal if the needle of a circuit tester does not move when control panel is knocked on.		
	Soldering in amplifier is faulty or contact condition in amplifier is faulty.	Take off thermister connector and short the amplifier side.	Chattering occurs when amplifier is knocked on.		Replace amplifier.
	Contact condition of connector is poor.	Move connectors.	Chattering occurs.	Connector is faulty.	Repair connector.
Temperature does not fall. (Cooling does not work well.) (Clutch makes on-off action.)	Thermister is deteriorated.	Replace thermister.	Cools off.	Thermister faulty.	Replace thermister.
	Mounting position of thermister is inadequate.	Move evaporator toward the center.	Does not cool off.	Thermister is faulty.	Replace thermister.
				Cooling capacity is not enough.	
	Amplifier inside is faulty.	Replace thermister.	Normal if cooling is enough.		
			Does not cool off.	Amplifier is taulty.	Replace amplifier.
Temperature does not fall. (Cooling does not work well.) (Clutch remains on.)	Something other than electronic thermostat is faulty. (Refer to the afore-mentioned Diagnosis table.				
Relays are noisy. (Chattering)	Contact condition of grounding line is faulty.	Confirm that grounding terminal is grounded correctly.	Normal.	Amplifier is faulty.	Replace.
			Connection is faulty.		Repair.

* Thermister is normal if temperature characteristics the thermister are 2kΩ at 0°C and 2.2kΩ at 25°C (77°F).

7.4 COMPRESSOR


Symptom and result of diagnosis
Cause
Remedy
Cooling not enough.
Compressor does not run
Clutch terminal voltage is normal. 12v or 24v.
Clutch is seized.
Replace.
Clearance between armature and rotor is improper. (Faulty air gap)
Core id disconnected or shorted.
Replace.
Shaft does not turn. (Internal lock)
Replace.
Clutch terminal voltage is low.
Clutch terminal voltage is zero.
(3) Refer to Electric Fault Diagnosis Table of Air-Conditioner.
Both compressor and blower motor run.
Both high and low pressures are lower than specified.
Air bubbles do not disappear even if gas is turned on.
Oil and/or gas leakage from parts other than compressor or pipe joints. Check with a gas detector.
(1) Refer to Fault Diagnosis Table of Refrigeration Circuit.
Gas or oil leakage from compressor (No gas or oil is leaking from something other than compressor.) Check with a gas detector.
Mechanical seal, gasket and charge valve.
Leakage from oil plug, etc.
Replace.
Leakage from the connecting part between front housing and cylinder block.
Replace.
Appearance is dirty.
(Refer to Note 1 and Note 2 on next page.)
Gas has not been charged for more than one season.
Natural leakage from hose, etc.
Charge gas.
Gas goes out within one to two months even if gas charged. Check with a gas detector.
Gas does not decrease two months after a gas charge.
No leakage. (Nothing abnormal)
High pressure is a little lower than specified and low pressure is higher than specified. (Air bubbles are seen through the sight glass.)
Compressor cylinder does not get hot. (Liquid pack)
Refer to Fault Diagnosis Table of Refrigeration Circuit.
Liquid pack is not applied. High pressure is lower than specified.
Valve is broken. (Refer to note 3 on next page.)
Gasket is punctured. (Refer to Note 3 on next page.)
Replace.
Others.
High pressure is higher than specified.
Cooling does not work gradually as compressor is run continuously.
Blower motor produces only a limited amount of flow.
(1) Refer to Fault Diagnosis Table of Refrigeration Circuit.
Too much oil.
Check oil and adjust oil level.
Tends to overheat.
Rotation of compressor is abnormally heavy.
Clutch bearing is faulty because of too much tension on belt.
Replace.
Shaft does not turn.
Shaft turn but is caught somehow.
Replace.
Symptom comes from something other than compressor.
(2) Refer to Fault Diagnosis Table of Refrigeration Circuit.

COMPRESSOR

Symptom and result of diagnosis			Cause	Remedy
Abnormal sound	Engine room side	When clutch is off.	Clutch bearing is faulty. (It roars.)	Replace.
			Contact and slippage due to faulty air gap.	
			Idle pulley bearing is faulty.	(2) Refer to Fault Diagnosis Table of Cooling Circuit.
			Belt is slack.	
			Screws are slack.	
		Abnormal sound is heard when clutch is on.	Valve is broken.	Replace.
			Gasket is punctured.	
			Abnormal sound is heard from inside.	Replace.
			Oscillation due to slackened V-belt.	(2) Refer to Fault Diagnosis Table of Cooling Circuit.
			Screws are loosened.	
	Compartment side	(2) Refer to Fault Diagnosis Table of Cooling Circuit.		

☞
- If you have found fouling near the clutch and the gasket, do not judge it a mere leakage resulting from fouling. Slight oozing of oil occurs due to the construction of the seal, but it will not develop any problem on it's performance. Therefore, determine it precisely if it is a leakage or a mere oozing.
- In the high sensitivity range of a gas detector, it sometimes detects a natural leakage from the rubber hose, depending upon condition, but it is of no problem with a designated rubber hose. (However, a fault of the hose is suspected when leakage is much.)
- If the compressor is idled for 10-15 minutes, the pressure difference between high and low levels is below 5kg/cm^2 (71psi) and the balance between high and low levels is broken within ten seconds when the clutch is turned off.

Book code No. S5LE5001E

KOBELCO

SHOP MANUAL SK60

ENGINE

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LE50

KOBE STEEL, LTD.

Applicable Machines
LE-11001~

Revision	Date of Issue	Remarks
First edition	June, 1990	S5LE5001E K

SECTION 1

GENERAL INFORMATION

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GENERAL REPAIR INSTRUCTIONS

1. Before performing any service operation with the engine mounted, disconnect the grounding cable from the battery.

   This will reduce the chance of cable damage and burning due to short circuiting.
2. Always use the proper tool or tools for the job at hand.

   Where specified, use the specially designed tool or tools.
3. Use genuine ISUZU parts.
4. Never reuse cotter pins, gaskets, O-rings, lock washers, and self locking nuts. Discard them as you remove them. Replace them with new ones.
5. Always keep disassembled parts neatly in groups. This will ensure a smooth reassembly operation.

   It is especially important to keep fastening parts separate. These parts vary in hardness and design, depending on their installation position.
6. All parts should be carefully cleaned before inspection or reassembly.

   Oil ports and other openings should be cleaned with compressed air to make sure that they are completely free of obstructions.
7. Rotating and sliding part surfaces should be lubricated with oil or grease before reassembly.
8. If necessary, use a sealer on gaskets to prevent leakage.
9. Nut and bolt torque specifications should be carefully followed.
10. Always release the air pressure from any machine-mounted air tank(s) before dismounting the engine or disconnecting pipes and hoses. To not do so is extremely dangerous.
11. Always check and recheck your work. No service operation is complete until you have done this.

NOTES ON THE FORMAT OF THIS MANUAL

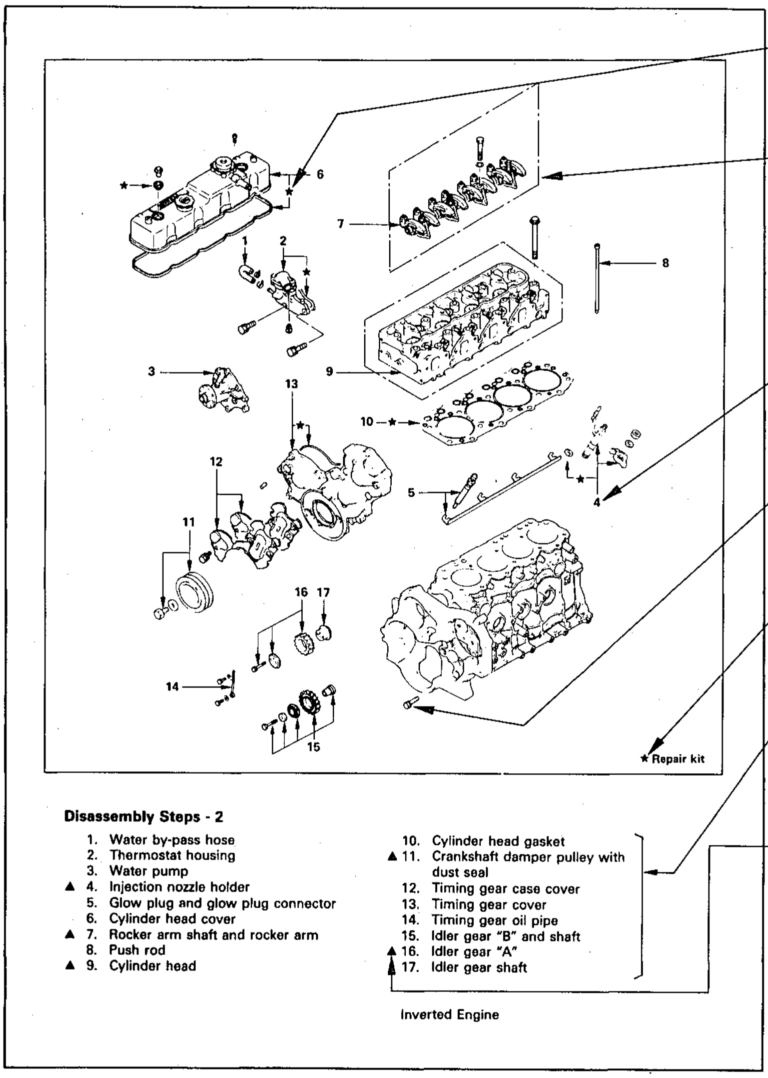
This Workshop Manual is applicable to ISUZU industrial engine or engines which is or are stated in the title.

When more than two engine models are dealt in the manual, such engines have common parts and components as well as data and specifications, unless otherwise specified.

1. Find the applicable section by referring to the Table of Contents at the beginning of the Manual.
2. Common technical data such as general maintenance items, service specifications, and tightening torques are included in the "General Information" section.

   The section ENGINE ASSEMBLY is an exception. This parts are divided in three sections to facilitates indexing.
3. Each section is divided into sub-sections dealing with disassembly, inspection and repair, and reassembly.

4. When the same servicing operation is applicable to several different units, the manual will direct you to the appropriate page.
5. For the sake of brevity, self-explanatory removal and installation procedures are omitted.
   More complex procedures are covered in detail.
6. Each service operation section in this Workshop Manual begins with an exploded view of the applicable area. A brief explanation of the notation used follows.



Disassembly Steps - 2

1. Water by-pass hose
2. Thermostat housing
3. Water pump
▲ 4. Injection nozzle holder
5. Glow plug and glow plug connector
6. Cylinder head cover
▲ 7. Rocker arm shaft and rocker arm
8. Push rod
▲ 9. Cylinder head
10. Cylinder head gasket
▲ 11. Crankshaft damper pulley with dust seal
12. Timing gear case cover
13. Timing gear cover
14. Timing gear oil pipe
15. Idler gear "B" and shaft
▲ 16. Idler gear "A"
▲ 17. Idler gear shaft

Inverted Engine

Parts marked with an asterisk (*) are included in the repair kit.

Parts within a square frame are to be removed and installed as a single unit, and their disassembly steps or reassembly steps are shown in the illustrations respectively.

The number tells you the service operation sequence.

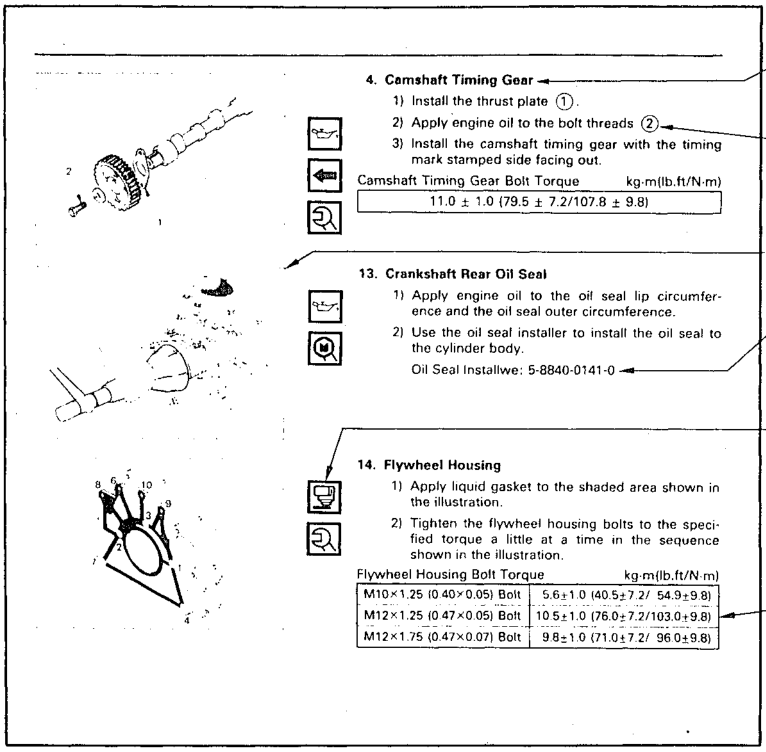
Removal of unnumbered parts is unnecessary unless replacement is required.

The "* Repair Kit" indicates that a repair kit is available.

The parts listed under "Disassembly Steps" or "Reassembly Steps" are in the service operation sequence.

The removal or installation of parts marked with a triangle (▲) is an important operation. Detailed information is given in the text.

7. Below is a sample of the text of the Workshop Manual.



4. Camshaft Timing Gear

1) Install the thrust plate ①.

2) Apply engine oil to the bolt threads ②.

3) Install the camshaft timing gear with the timing mark stamped side facing out.

Camshaft Timing Gear Bolt Torque kg·m(lb.ft/N·m)

11.0 ± 1.0 (79.5 ± 7.2/107.8 ± 9.8)

13. Crankshaft Rear Oil Seal

1) Apply engine oil to the oil seal lip circumference and the oil seal outer circumference.

2) Use the oil seal installer to install the oil seal to the cylinder body.

Oil Seal Installwe: 5-8840-0141-0

14. Flywheel Housing

1) Apply liquid gasket to the shaded area shown in the illustration.

2) Tighten the flywheel housing bolts to the specified torque a little at a time in the sequence shown in the illustration.

Flywheel Housing Bolt Torque kg·m(lb.ft/N·m)

M10×1.25 (0.40×0.05) Bolt	5.6±1.0 (40.5±7.2/ 54.9±9.8)
M12×1.25 (0.47×0.05) Bolt	10.5±1.0 (76.0±7.2/103.0±9.8)
M12×1.75 (0.47×0.07) Bolt	9.8±1.0 (71.0±7.2/ 96.0±9.8)

This is the item shown in the illustration. It is marked with a triangle (▲) on the Major Components page.

Letters and numbers contained in a circle refer to the illustration.

Special tools are identified by the tool name and/or number.

The illustration shows how the special tool is to be used.

Symbols indicate the type of service operation or step to be performed. A detailed explanation of these symbols follows.

Service data and specifications are given in this table.

8. The following symbols appear throughout this Workshop Manual. They tell you the type of service operation or step to perform.

···· Removal

···· Installation

···· Disassembly

···· Reassembly

···· Alignment (marks)

···· Directional indication

···· Inspection

···· Measurement

···· Adjustment

···· Cleaning

···· Important operation requiring extra care

···· Specified torque (tighten)

···· Special tool use required or recommended (Isuzu tool or tools)

···· Commercially available tool use required or recommended

···· Lubrication (oil)

···· Lubrication (grease)

···· Liquid gasket application

9. Measurement criteria are defined by the terms "standard" and "limit".

   A measurement falling within the "standard" range indicates that the applicable part or parts are serviceable.

   "Limit" should be thought of as an absolute value.

   A measurement which is outside the "limit" indicates that the applicable part or parts must be either repaired or replaced.

10. Components and parts are listed in the singular form throughout the Manual.
11. Directions used in this Manual are as follows:

    Front

    The cooling fan side of the engine viewed from the flywheel.

    Right

    The right hand side viewed from the same position.

    Left

    The left hand side viewed from the same position.

    Rear

    The flywheel side of the engine.

    Cylinder numbers are counted from the front of the engine.

    The front most cylinder is No. 1 and rear most cylinder is the final cylinder number of the engine.

    The engine's direction of rotation is counterclockwise viewed from the flywheel.

MAIN DATA AND SPECIFICATIONS

Engine Model / Item	4JA1	4JB1	4JC1
Engine type	Water cooled, four-cycle, in-line, overhead valve		
Combustion chamber type	Direct injection		
Cylinder liner type	Dry		
No. of cylinders - Bore x Stroke mm(in.)	4-93.0x92.0 (3.66x3.62)	4-93.0x102.0 (3.66x4.02)	4-88.0x92.0 (3.46x3.62)
Total piston displacement cm^3(in^3)	2,499(152.4)	2,771(169.0)	2,238(136.5)
Compression ratio (To 1)	18.4	18.2	19.0
*Engine dimensions mm(in.)	805x590x725	805x590x750	717x590x725
Length x Width x Height	(31.7x23.2x28.5)	(31.7x23.2x29.5)	(28.2x23.2x28.5)
*Engine weight (Dry) kg(lb.)	218 (480)	220 (486)	218 (480)
Fuel injection order	1—3—4—2		
*Fuel injection timing (B.T.D.C.) degrees	17		
Specified fuel	Diesel fuel		
Injection pump	In-line plunger, Bosch A type		
Governor	Mechanical, RSV type		
*Low idle speed rpm	650—1,350		
Injection nozzle	Hole type (with 4 orifices)		
Injection starting pressure kg/cm^2(psi)/kPa)	185 (2630/18,142)		
Fuel filter type	Cartridge papaer element		
Water sedimentor (if so equipped)	Sediment/water level indicating type		
Compression pressure kg/cm^2(psi)/kPa)	31 (441/3,041)		
Valve clearance (at cold) Intake mm(in.)	0.40 (0.016)		
Exhaust mm(in.)	0.40 (0.016)		
Lubrication method	Pressurized circulation		
Oil pump	Trochoid type		
Main oil filter type	Cartridge paper element, full flow		
Partial oil filter	Not equipped		
*Lubricating oil capacity lit.(US/UK gal.)	5.5 (1.45/1.21)		
Oil cooler (if so equipped)	Water cooled built in oil filter		
Cooling method	Pressurized forced circulation		
Coolant capacity lit.(US/UK gal.)	5.0 (1.32/1.10)		
Water pump	Belt driven impeller type		
Thermostat type	Wax pellet type		
*Alternator V-A	12—35 or 24—45 or 24—20		
*Starter V-kW	12—2.2 or 24—3.5		

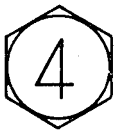
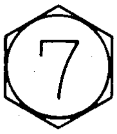
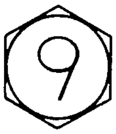
Specifications marked with an asterisk (*) will vary according to engine application.

TIGHTENING TORQUE SPECIFICATION

STANDARD BOLTS

The torque values given in the following table should be applied where a particular torque is not specified.

kg·m(lb.ft./N·m)

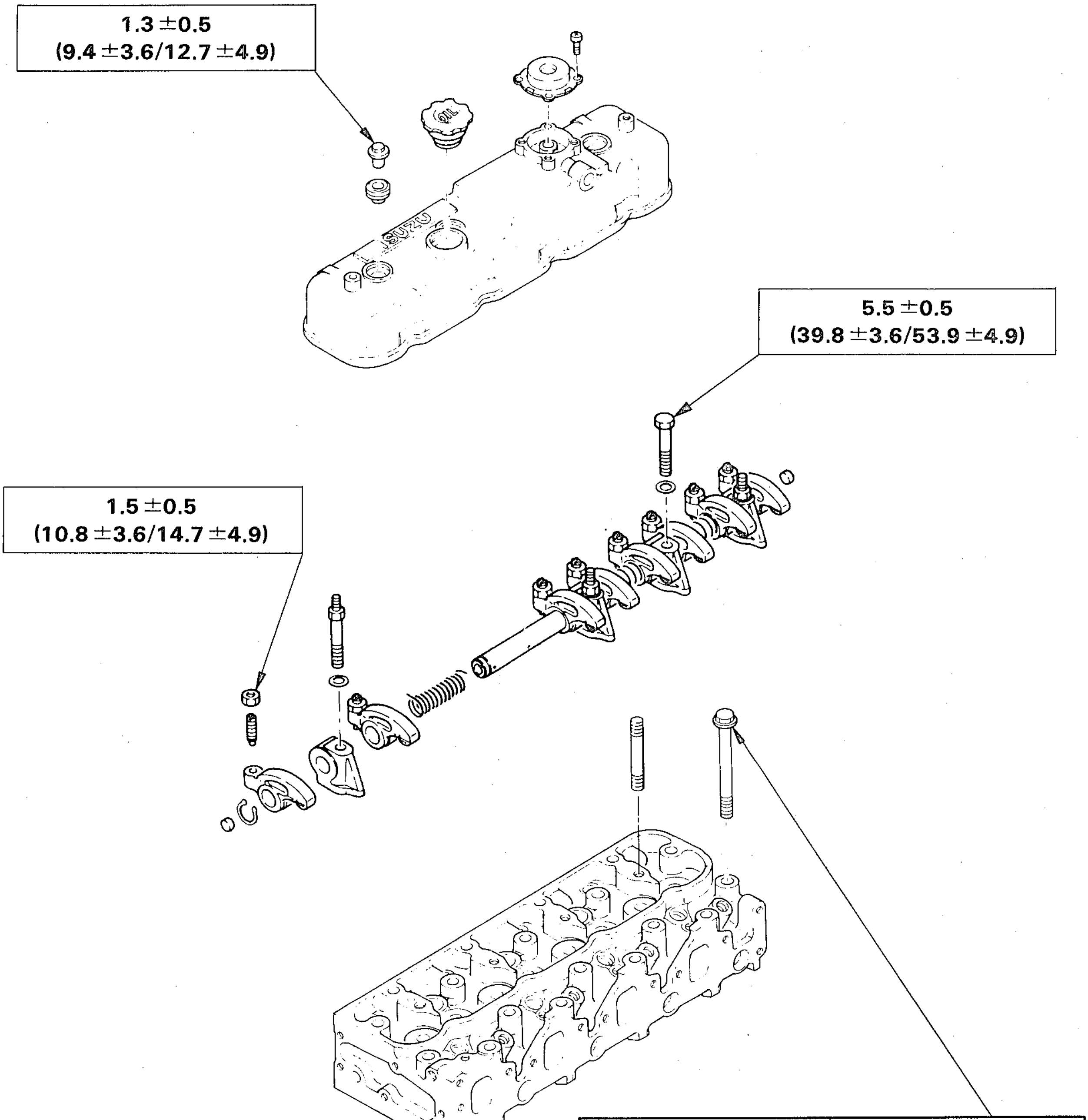
Bolt identification			
Bolt diameter x pitch (mm)	4T (Low carbon steel)	7T (High carbon steel)	9T (Alloy steel)
M 6 x 1.0	0.6 ± 0.2 (4.4 ± 1.4 / 5.88± 1.96)	0.75± 0.2 (5.43± 1.43/ 7.35± 1.96)	—
M 8 x 1.25	1.3 ± 0.5 (0.4 ± 3.4 / 12.74± 4.90)	1.75± 0.5 (12.66± 3.00/ 17.15± 4.90)	2.0 ± 0.7 (17.36± 5.36/ 19.60± 6.86)
M10 x 1.25	2.8 ± 0.7 (20.3 ± 5.2 / 27.44± 6.86)	3.75± 0.9 (27.20± 7.2 / 36.75± 8.82)	5.0 ± 1.3 (36.88± 9.88/ 49.00± 12.74)
M12 x 1.25	6.25± 1.2 (45.2 ± 9.2 / 61.25± 11.76)	7.75± 1.5 (56.03± 11.03/ 75.95± 14.70)	9.65± 1.9 (69.77± 13.77/ 94.57± 18.62)
M14 x 1.5	8.75± 1.9 (70.5 ± 14.5 / 85.75± 18.62)	11.85± 2.3 (85.67± 16.6 /116.13± 22.54)	14.5 ± 2.9 (104.84± 20.83/142.1 ± 28.42)
M16 x 1.5	13.3 ± 2.7 (94.0 ± 17.0 /130.34± 26.46)	17.35± 3.5 (125.07± 25.07/169.54± 34.30)	20.4 ± 4.1 (147.5 ± 29.49/199.92± 40.18)
M18 x 1.5	19.2 ± 3.8 (138.9 ± 27.9 /188.16± 37.24)	24.90± 5.0 (180.03± 36.3 /244.02± 4.90)	29.30± 5.9 (211.84± 42.83/287.14± 57.82)
M20 x 1.5	26.3 ± 5.3 (190.2 ± 38.2 /257.74± 51.94)	34.40± 6.9 (248.72± 49.7 /337.12± 67.62)	40.40± 8.1 (292.10± 58.09/395.92± 79.38)
M22 x 1.5	33.0 ± 8.3 (245.1 ± 60.1 /323.40± 81.34)	46.25± 9.2 (334.39± 66.38/453.25± 90.16)	54.10±10.8 (391.15± 78.14/530.18±105.84)
M24 x 2.0	45.8 ± 9.2 (331.2 ± 60.2 /448.84± 90.16)	58.20±14.0 (420.70±102.78/570.36±137.20)	70.60±14.1 (510.44±101.44/691.88±138.18)
*M10 x 1.5	2.7 ± 0.7 (19.6 ± 5.6 / 26.46± 6.86)	3.7 ± 0.9 (26.75± 6.7 / 36.26± 8.82)	4.9 ± 1.2 (35.43± 8.42/ 48.02± 11.76)
*M12 x 1.5	5.8 ± 1.2 (42.0 ± 9.0 / 56.84± 11.76)	7.2 ± 1.4 (52.02± 10.05/ 70.56± 13.72)	9.1 ± 1.8 (65.80± 12.80/ 89.18± 17.64)
*M14 x 2.0	9.1 ± 1.8 (65.8 ± 12.8 / 89.18± 17.64)	11.2 ± 2.2 (80.97± 15.7 /109.76± 21.56)	13.6 ± 2.7 (98.33± 19.33/133.28± 26.46)
*M16 x 2.0	12.7 ± 2.5 (91.9 ± 17.9 /124.46± 24.5)	16.5 ± 3.3 (119.30± 24.3 /161.70± 32.34)	19.5 ± 3.9 (140.99± 27.99/191.1 ± 38.22)

Note:
The asterisk (*) indicates that the bolts are used for female-threaded parts that are made of soft materials such as casting.

SPECIAL PARTS FIXING NUTS AND BOLTS

Cylinder Head Cover, Cylinder Head, and Rocker Arm Shaft Bracket

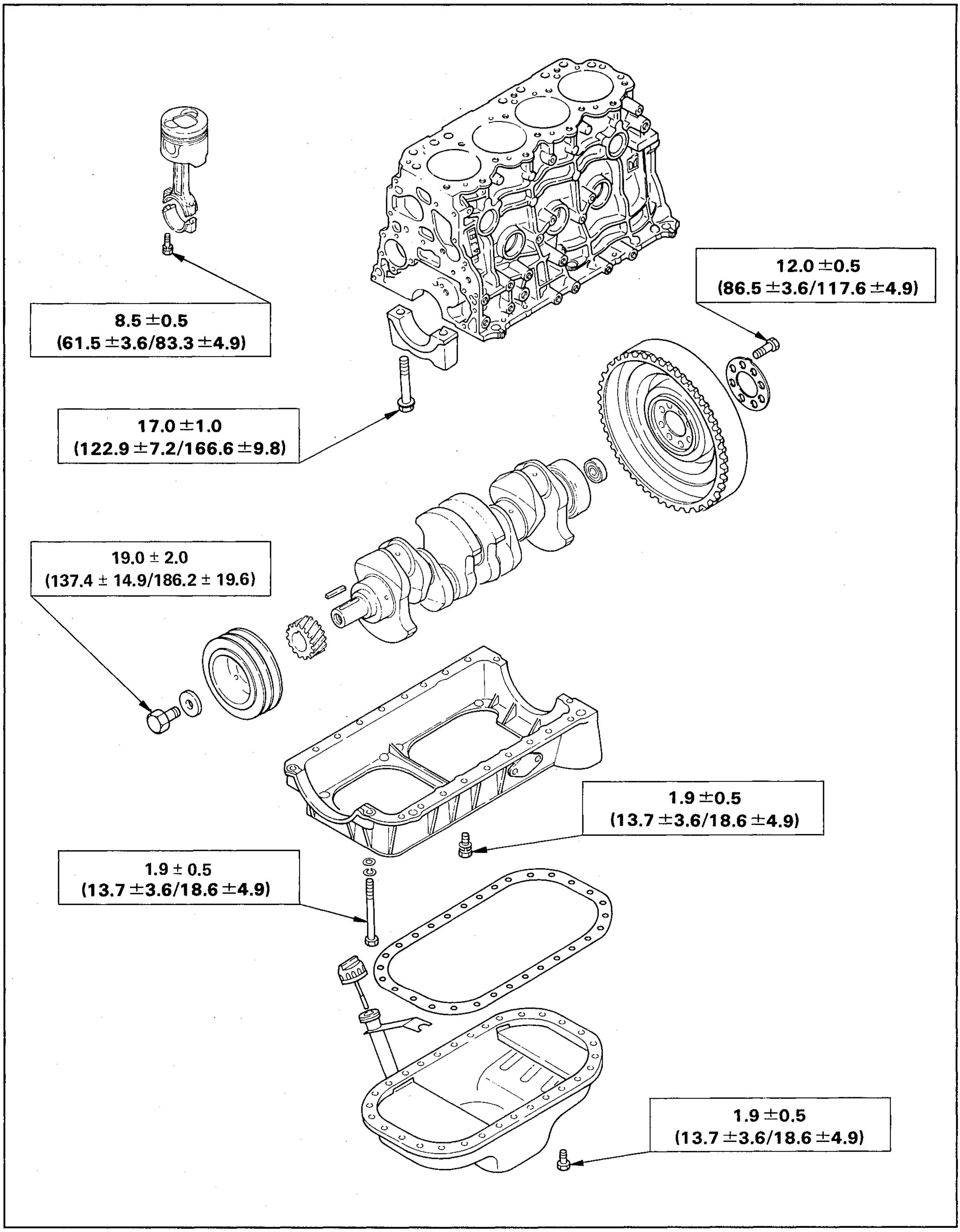
kg·m(lb.ft./N·m)


1.3 ±0.5
(9.4 ±3.6/12.7 ±4.9)
OIL
ISUZU
5.5 ±0.5
(39.8 ±3.6/53.9 ±4.9)
1.5 ±0.5
(10.8 ±3.6/14.7 ±4.9)

	1st Step	2nd Step
New bolt	4.0 ±1.0 (28.9 ±7.2/39.0 ±9.8)	8.7 ±0.5 (63.0 ±3.6/85.3 ±4.9)
Reused bolt	8.5 ±0.5 (61.5 ±3.6/83.3 ±4.9)	10.5 ±0.5 (76.0 ±3.6/103.0 ±4.9)

Crankshaft Bearing Cap, Connecting Rod Bearing Cap, Crankshaft Damper Pulley, Flywheel, and Oil Pan

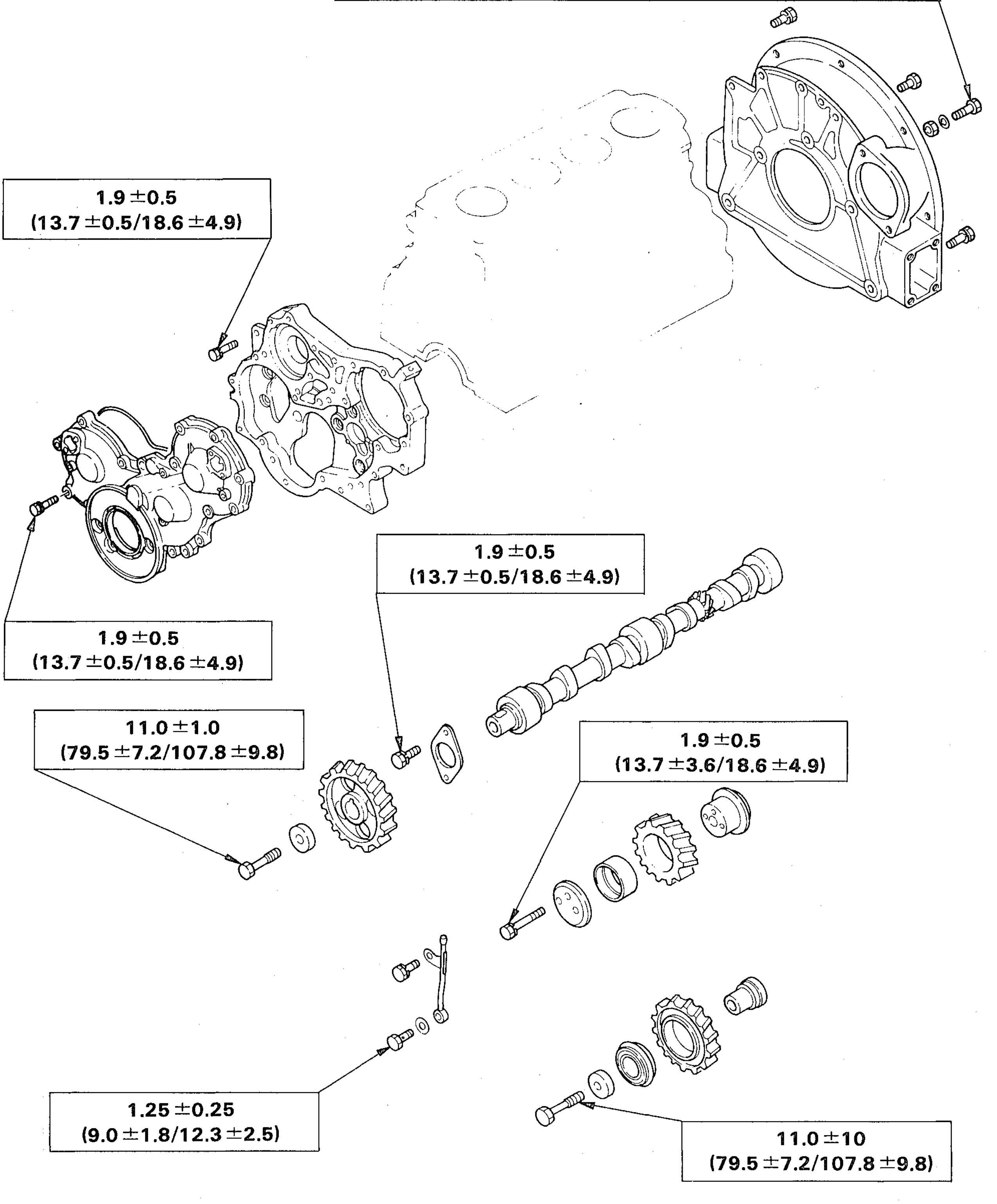
kg·m(lb.ft./N·m)


12.0 ±0.5
(86.5 ±3.6/117.6 ±4.9)
8.5 ±0.5
(61.5 ±3.6/83.3 ±4.9)
17.0 ±1.0
(122.9 ±7.2/166.6 ±9.8)
19.0 ± 2.0
(137.4 ± 14.9/186.2 ± 19.6)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ± 0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)

Timing Gear Case, Flywheel Housing, Camshaft, and Timing Gear

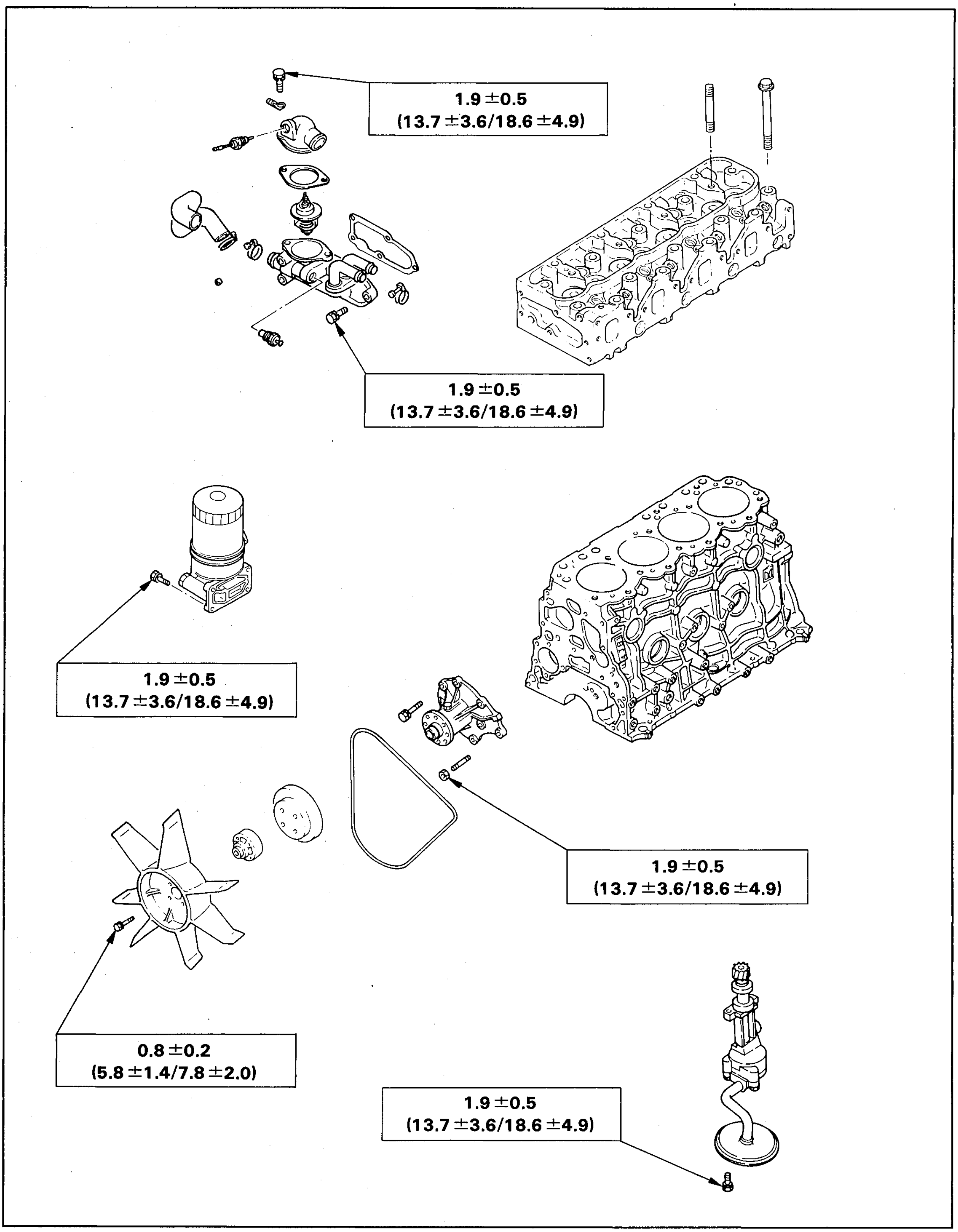
kg·m(lb.ft./N·m)

M10x1.25 (0.39x0.05)	5.6 ±1.0 (40.5 ±7.2/54.9 ±9.8)
M10x1.25 (0.39x0.05)	10.6 ±1.0 (75.9 ±7.2/102.7 ±9.8)
M12x1.75 (0.47x0.07)	9.8 ±1.0 (70.9 ±7.2/96.0 ±9.8)


1.9 ±0.5
(13.7 ±0.5/18.6 ±4.9)
1.9 ±0.5
(13.7 ±0.5/18.6 ±4.9)
1.9 ±0.5
(13.7 ±0.5/18.6 ±4.9)
11.0 ±1.0
(79.5 ±7.2/107.8 ±9.8)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.25 ±0.25
(9.0 ±1.8/12.3 ±2.5)
11.0 ±10
(79.5 ±7.2/107.8 ±9.8)

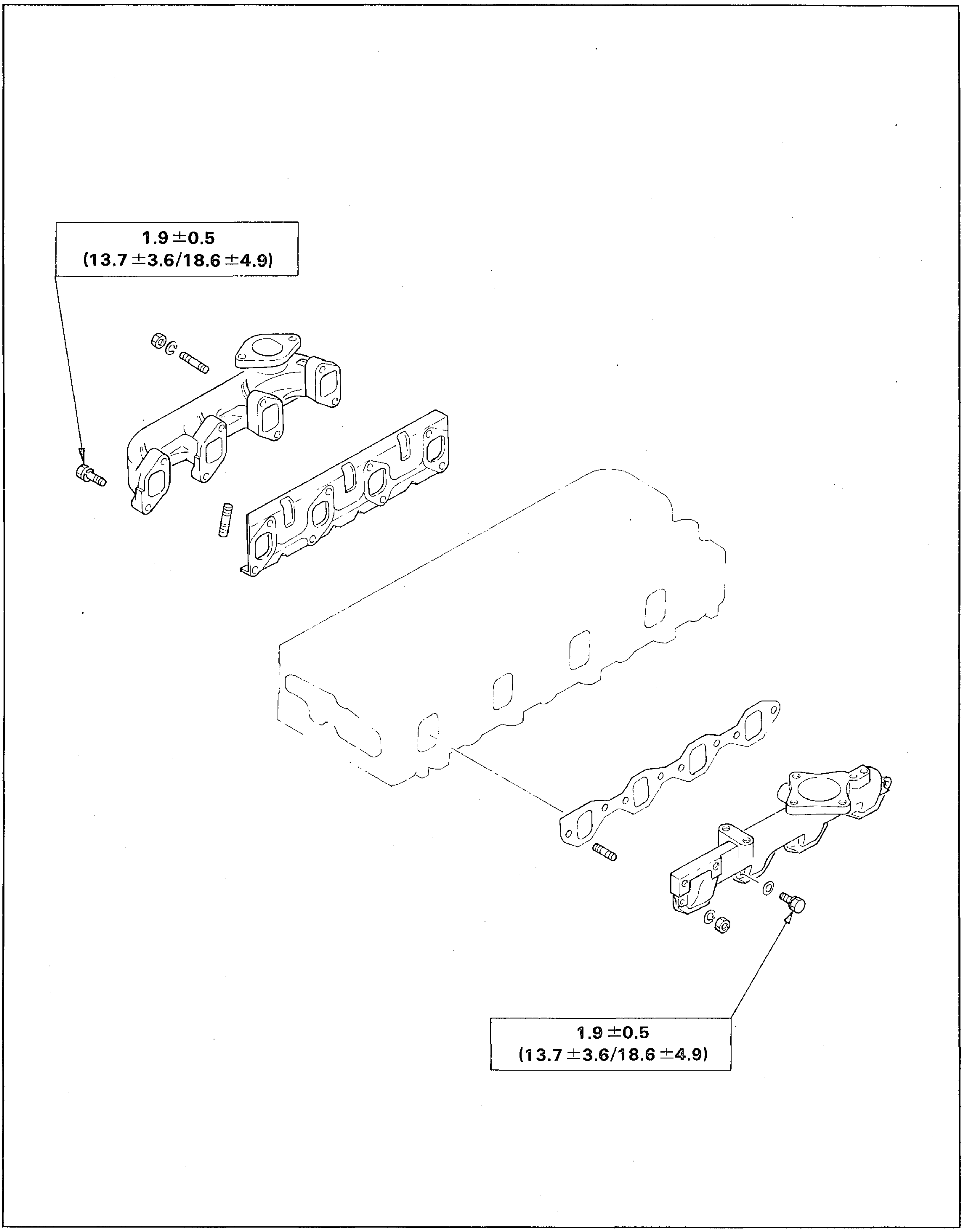
Cooling and Lubricating System

kg·m(lb.ft./N·m)


1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
0.8 ±0.2
(5.8 ±1.4/7.8 ±2.0)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)

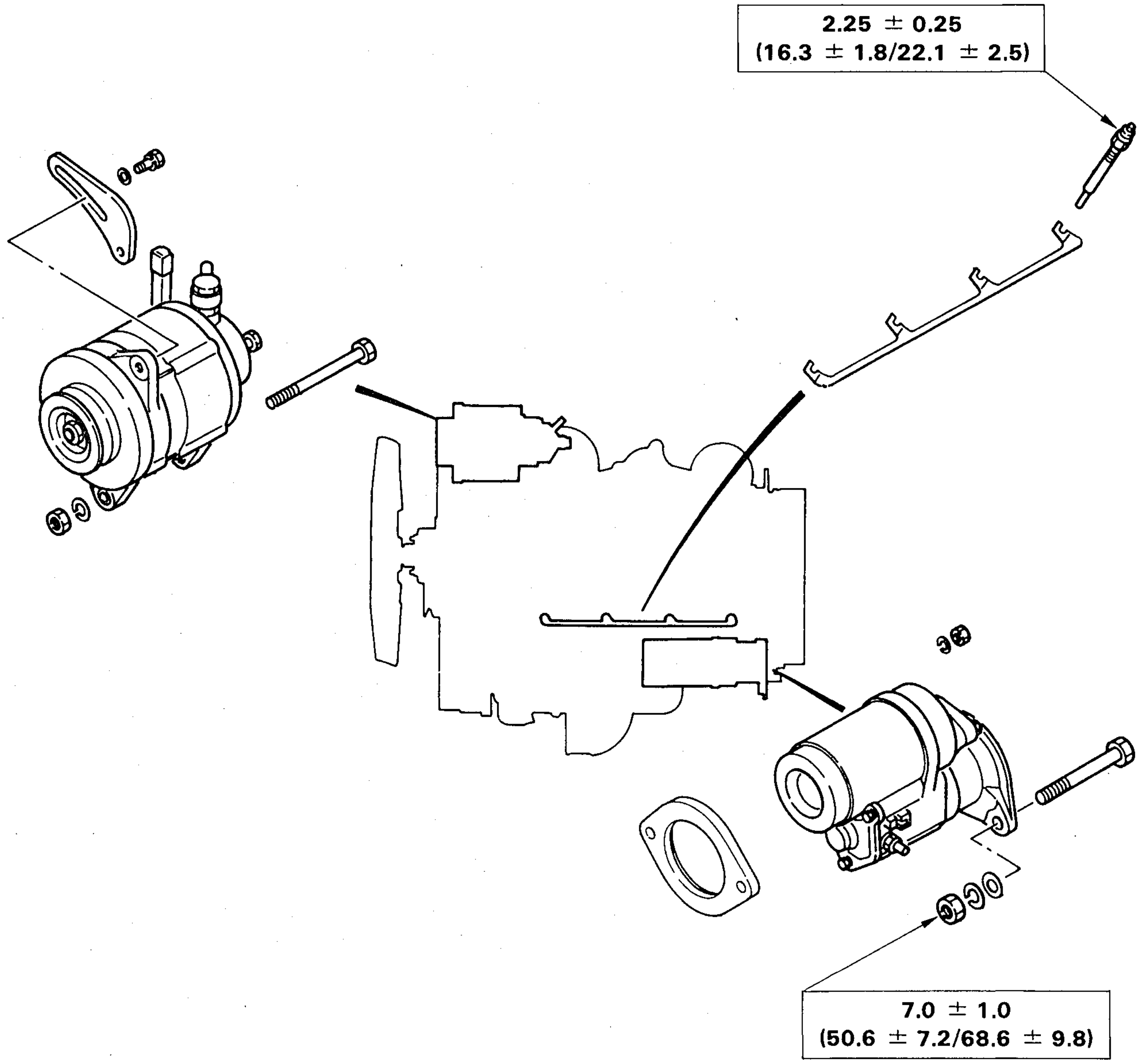
Intake and Exhaust Manifold

kg·m(lb.ft./N·m)


1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)

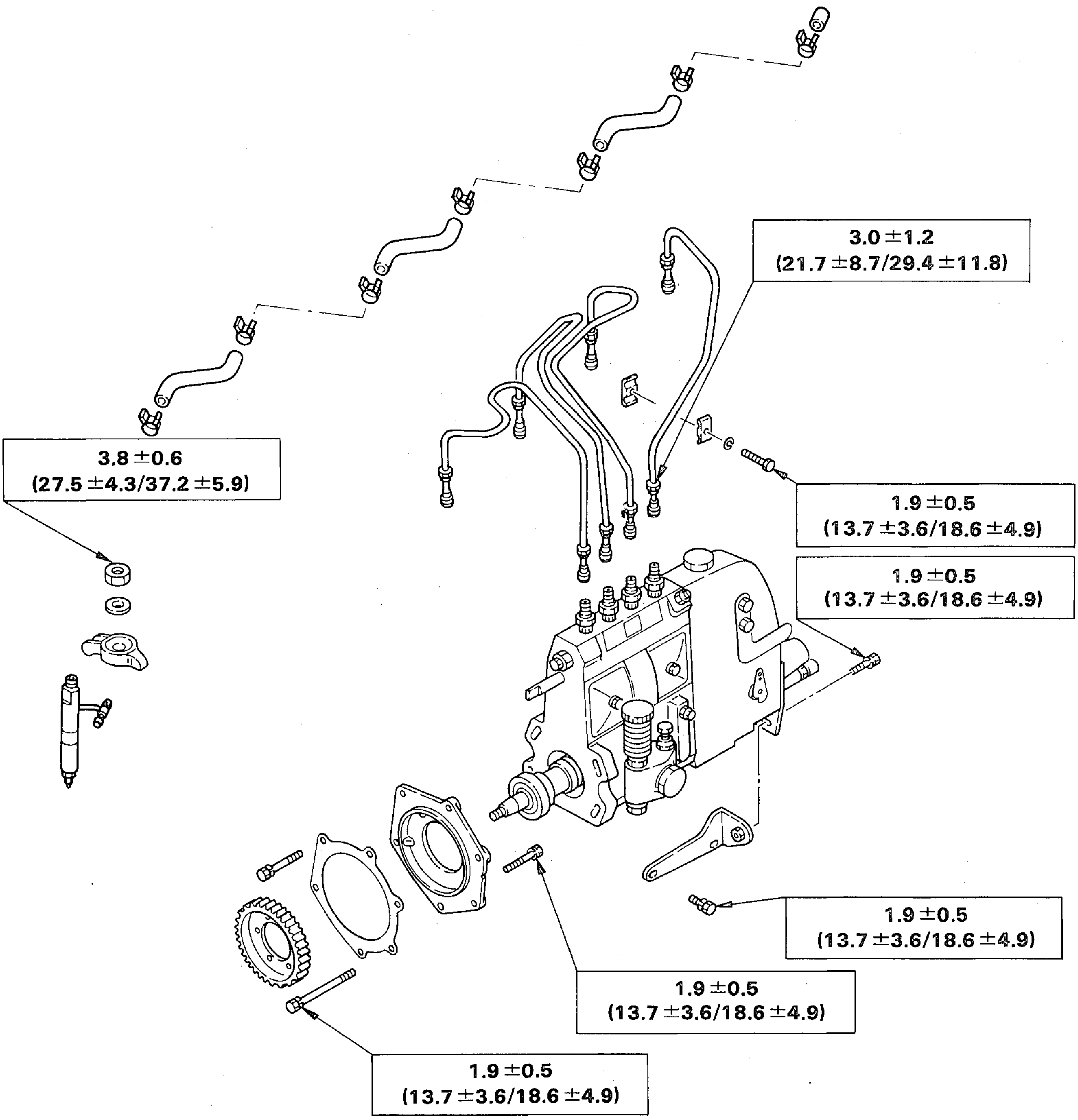
Engine Electrical

kg·m(lb.ft./N·m)


2.25 ± 0.25
(16.3 ± 1.8/22.1 ± 2.5)
7.0 ± 1.0
(50.6 ± 7.2/68.6 ± 9.8)

Fuel Injection System

kg·m(lb.ft./N·m)


3.0 ±1.2
(21.7 ±8.7/29.4 ±11.8)
3.8 ±0.6
(27.5 ±4.3/37.2 ±5.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)
1.9 ±0.5
(13.7 ±3.6/18.6 ±4.9)

SECTION 2

MAINTENANCE

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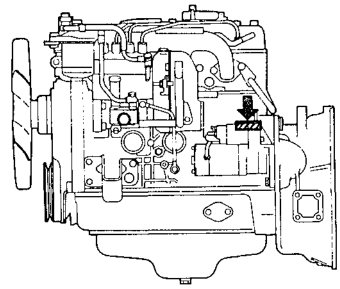
Model identification .... 2— 2
Injection pump identification .... 2— 2
Lubricating system .... 2— 2
Fuel system .... 2— 3
Cooling system .... 2— 6
Valve clearance adjustment .... 2— 7
Injection timing .... 2— 8
Compression pressure measurement .... 2— 9
Recommended lubricants .... 2—10
Repair kits .... 2—11

MAINTENANCE

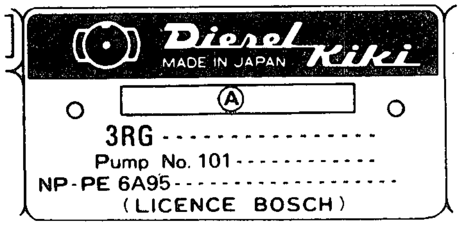
Servicing refers to general maintenance procedures to be performed by qualified service personnel.
Maintenance interval such as fuel or oil filter changes should be refered to "INSTRUCTION MANUAL".



MODEL IDENTIFICATION

Engine Serial Number

The engine number is stamped on the rear left hand side of the cylinder body.



Ⓐ--- Identification number

0K307

INJECTION PUMP IDENTIFICATION

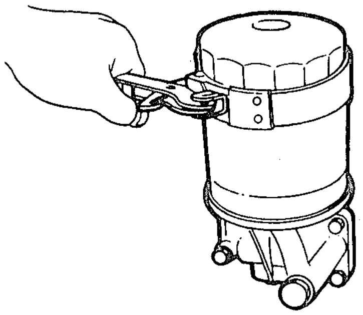
Injection volume should be adjusted after referring to the adjustment data applicable to the injection pump installed.

The injection pump identification number (A) is stamped on the injection pump identifications plate.

Note:

Always check the identification number before beginning a service operation.

Applicable service data will vary according to the identification number. Use of the wrong service data will result in reduced engine performance and engine damage.



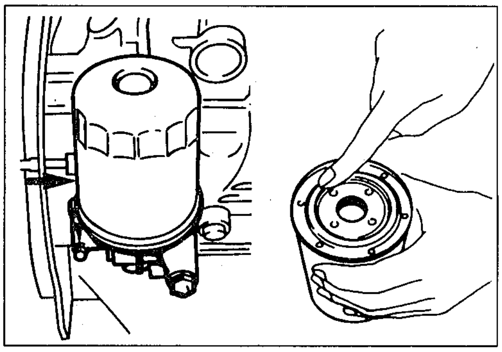
LUBRICATING SYSTEM

Main Oil Filter

Replacement Procedure

1. Loosen the drain plug to drain the engine oil.
2. Wait a few minutes and then retighten the drain plug.
3. Loosen the used oil filter by turning it counterclockwise with a filter wrench.
   Filter Wrench

4. Clean the oil cooler fitting face.
   This will allow the new oil filter to seat properly.
5. Apply a light coat of engine oil to the O-ring.
6. Turn in the new oil filter until the filter O-ring is fitted against the sealing face.



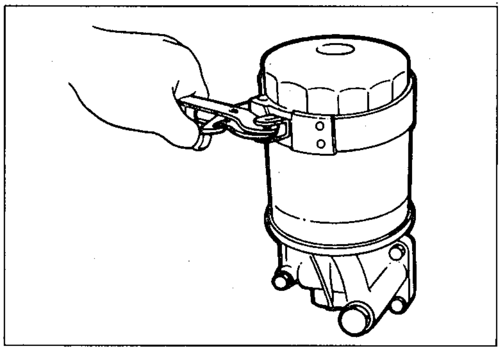
7. Use a filter wrench to turn in the filter an additional 1 and 1/4 turns.

   Filter Wrench
8. Check the engine oil level and replenish to the specified level if required.
9. Start the engine and check for oil leakage from the main oil filter.

FUEL SYSTEM

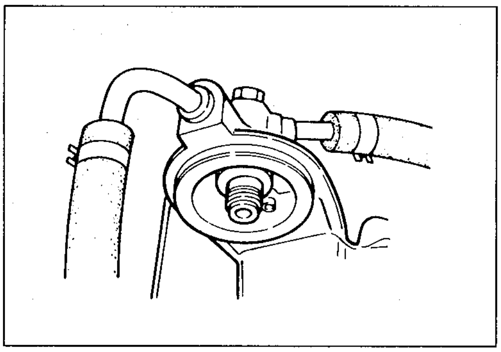
Fuel Filter

Replacement Procedure



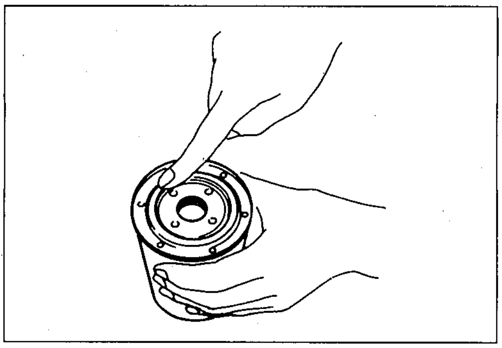
1. Loosen the used fuel filter by turning it counterclockwise with the filter wrench.

   Filter Wrench



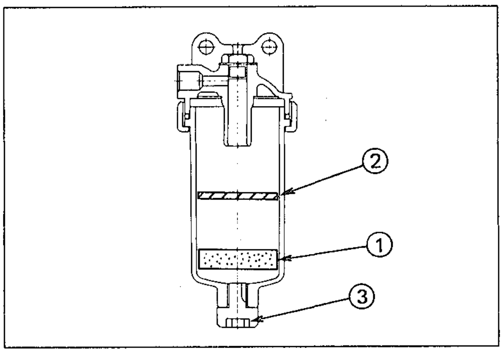
2. Clean the upper cover fitting face.

   This will allow the new fuel filter to seat properly.



3. Apply a light coat of engine oil to the O-ring.
4. Supply fuel to the new fuel filter to facilitate bleeding.
5. Turn in the new fuel filter until the filter O-ring is fitted against the sealing face.

   Be very careful to avoid fuel spillage.
6. Use a filter wrench to turn in the fuel filter an additional 1/3 to 2/3 of a turn.

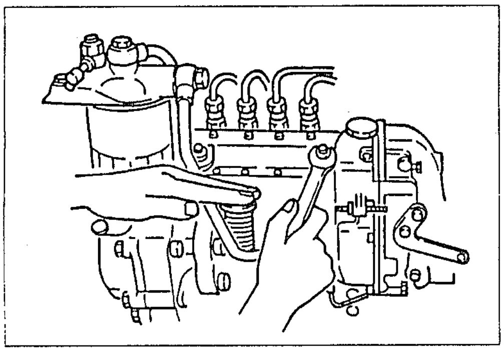


Water Separator (Water Sedimentor) (Optional Equipment)

Check the water separator float ① level.

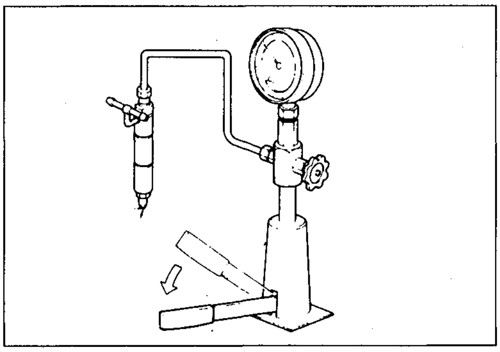
If the float ① has reached level ②, loosen the drain plug ③ (at the bottom side of the water separator) to drain the water.

Drain Plug Torque	kg·m(lb.ft./N·m)
1.2 ± 0.3 (8.68 ± 2.7/11.8 ± 2.9)	



Air Bleeding

1. Loosen the priming pump cap ① on the injection pump.
2. Loosen the fuel return eye bolt ② on the fuel filter.
3. Operate the priming pump until there are no more bubbles visible in the fuel being discharged from the fuel return eye bolt on the fuel filter.
4. Retighten the fuel return eye bolt on the fuel filter.
5. Loosen the bleeder bolt ③ while operating the injection pump priming pump to check that the air has been bled completely.
6. Operate the priming pump several times to check for fuel leakage around the injection pump and the fuel filter.



Injection Nozzle

Injection Nozzle Inspection

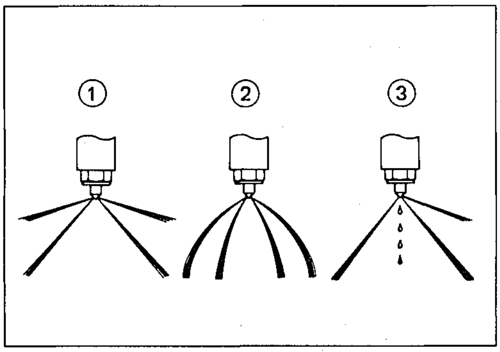
Use a nozzle tester to check the injection nozzle opening pressure and the spray condition.

If the opening pressure is above or below the specified value, the injection nozzle must be replaced or reconditioned.

If the spray condition is bad, the injection nozzle must be replaced or reconditioned.

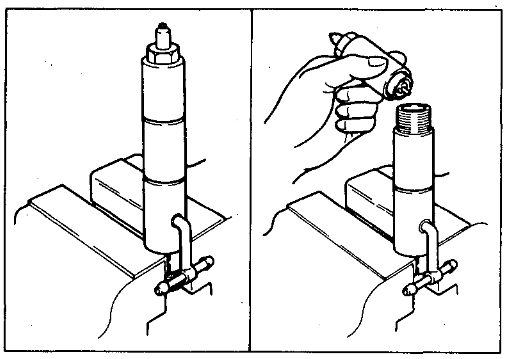
Injection Nozzle Opening Pressure kg/cm^2(psi/kPa)

185 (2,630/18,142)



Spray Condition

(1) Correct
(2) Incorrect (Restrictions in orifice)
(3) Incorrect (Dripping)

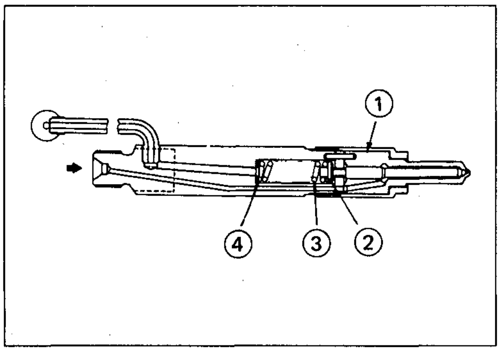


Injection Nozzle Adjustment

1. Clamp the injection nozzle in a vise.
2. Use a wrench to remove the injection nozzle retaining nut.
3. Install the injection nozzle ①, the push rod ②, the spring ③, and adjusting shim ④.

Retaining Nut Torque kg·m(lb.ft./N·m)

4.5 ± 0.5 (32.5 ± 3.6/44.0 ± 4.9)



4. Attach the injection nozzle holder to the injection nozzle tester.
5. Apply pressure to the nozzle tester to check that the injection nozzle opens at the specified pressure.

   If the inejection nozzle does not open at the specified pressure, install or remove the appropriate number of adjusting shims to adjust it.

Adjusting Shim Availability mm(in.)

Range	0.50—1.50 (0.02—0.06)
Increment	0.025 (0.001)

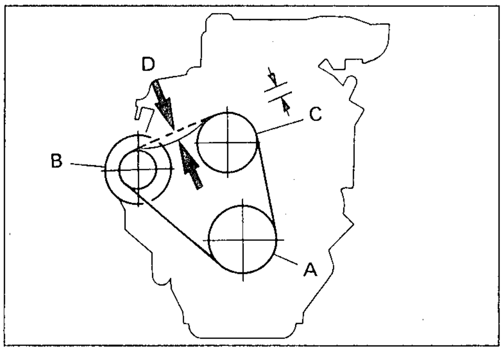
Total No. of Shims 40

(Reference)

Removing or installing one shim will increase or decrease the nozzle opening pressure approximately 3.77 kg/cm^2 (53.6 psi/370kPa).

WARNING:

TEST FLUID FROM THE INJECTION NOZZLE TESTER WILL SPRAY OUT UNDER GREAT PRESSURE. IT CAN EASILY PUNCTURE A PERSON'S SKIN. KEEP YOUR HANDS AWAY FROM THE INJECTION NOZZLE TESTER AT ALL TIMES.



COOLING SYSTEM

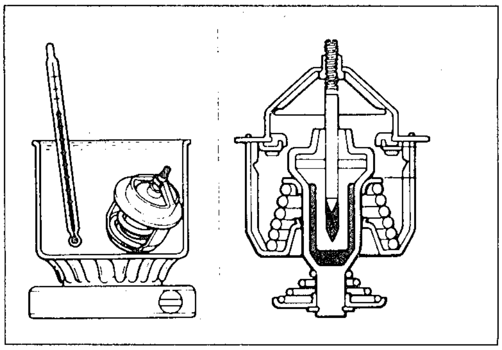
Cooling Fan Drive Belt

Fan belt tension is adjusted by moving the alternator.

A Crankshaft damper pulley
B Alternator pulley
C Cooling fan drive pulley
D Depress the drive belt mid-portion with a 10 kg (22 lb/98 N) force.

Drive Belt Deflection mm(in.)

10.0 (0.39)

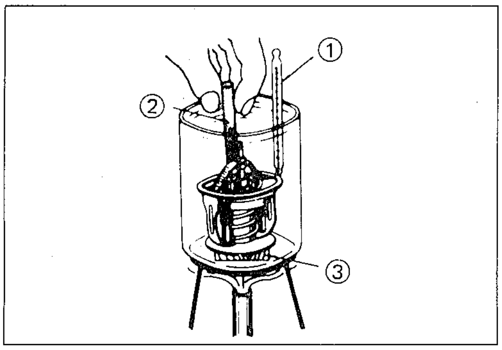


Thermostat

Operating Test

1. Completely submerge the thermostat in water.
2. Heat the water.

   Stir the water constantly to avoid direct heat being applied to the thermostat.



3. Check the thermostat initial opening temperature.

Thermostat Initial Opening Temperature °C(°F)

82 (182)

4. Check the thermostat full opening temperature.

Thermostat Full Opening Temperature °C(°F)

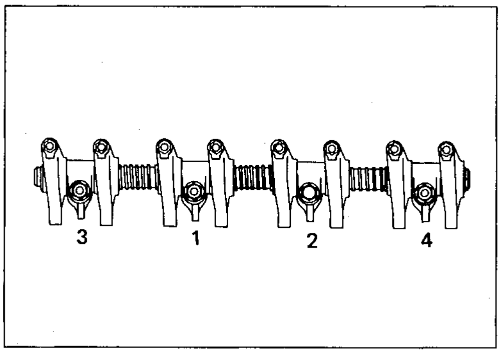
95 (203)

Valve Lift at Fully Open Position mm(in.)

8.0 (0.31)

① Thermostat
② Agitating Rod
③ Wooden Piece

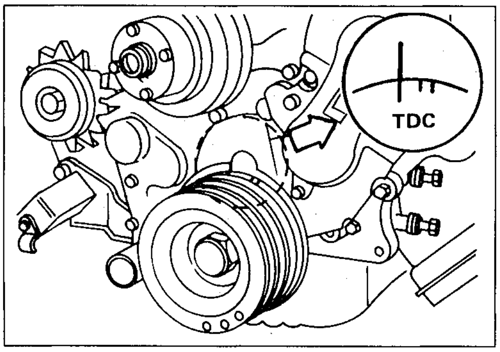
VALVE CLEARANCE ADJUSTMENT



1. Retighten the rocker arm shaft bracket bolts in sequence as shown in the illustration.

Rocker Arm Shaft Bracket Bolt
Torque kg·m(lb.ft./N·m)

5.5 ± 0.5 (39.8 ± 3.6/53.9 ± 4.9)

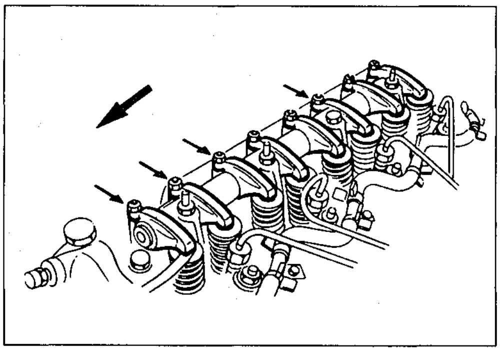


2. Bring the piston in either the No. 1 cylinder or the No. 4 cylinder to TDC on the compression stroke by turning the crankshaft until the crankshaft damper pulley TDC line is aligned with the timing pointer.

3. Check for play in the No. 1 intake and exhaust valve push rods.

   If the No. 1 cylinder intake and exhaust valve push rods have play, the No. 1 piston is at TDC on the compression stroke.

   If the No. 1 cylinder intake and exhaust valve push rods are depressed, the No. 4 piston is at TDC on the compression stroke.

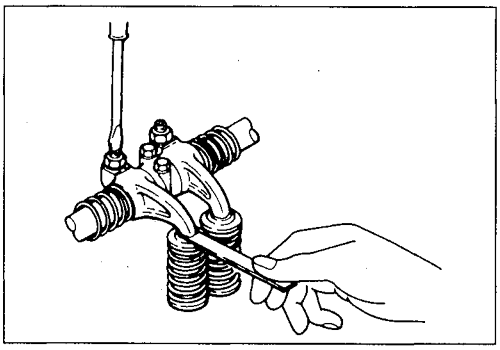


Adjust the No. 1 or the No. 4 cylinder valve clearances while their respective cylinders are at TDC on the compression stroke.

Valve Clearance mm(in.)

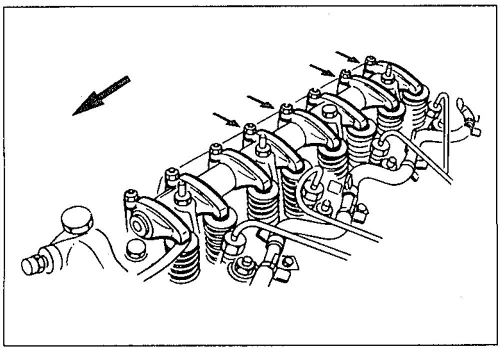
0.40 (0.016)

Loosen each valve clearance adjusting screw as shown in the illustration. (At TDC on the compression stroke of the No. 1 cylinder)



Insert a feeler gauge of the appropriate thickness between the rocker arm and the valve stem end.

4. Turn the valve clearance adjusting screw until a slight drag can be felt on the feeler gauge.
5. Tighten the lock nut securely.



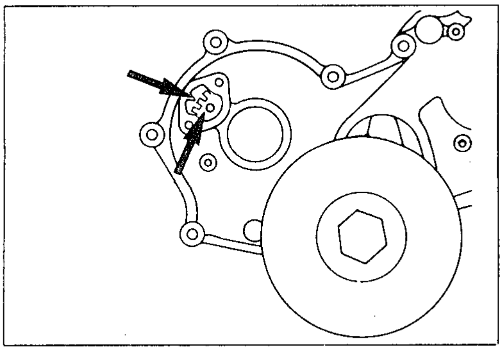
Rotate the crankshaft 360°.

Realign the crankshaft damper pulley TDC line with the timing pointer.

Adjust the clearances for the remaining valves as shown in the illustration. (At TDC on the compression stroke of the No. 4 stroke)

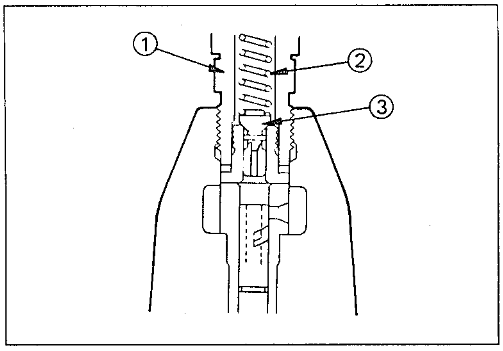
INJECTION TIMING

Injection Timing Confirmation Procedure



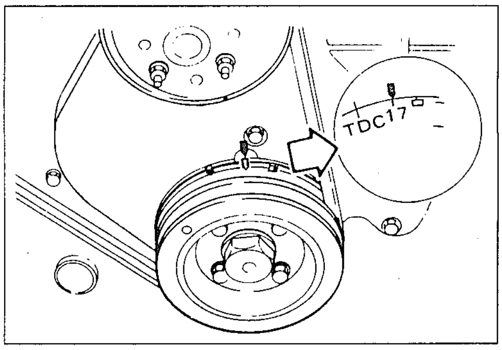
1. Rotate the crankshaft clockwise to align the camshaft gear timing mark "O" with the timing gear case cover pointer.

   The No. 1 cylinder will now be at the point where nearly injection timing.
2. Remove the No. 1 fuel injection pipe.



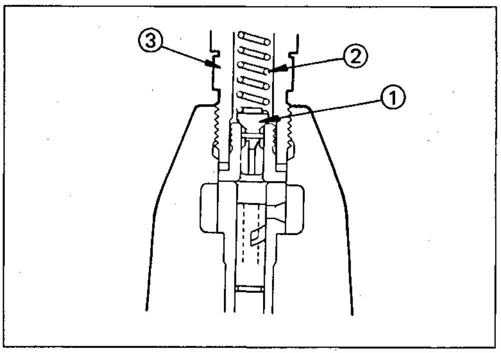
3. Remove the delivery valve holder ①, the delivery valve spring ②, and the delivery valve ③.
4. Tighten the delivery valve holder to the specified torque.

Delivery Valve Holder Torque	kg·m(lb.ft/N·m)
4.25 ± 0.25 (30.7 ± 1.8/41.7 ± 2.5)	



5. Operate the injection pump priming pump while slowly rotating the crankshaft until fuel stops flowing from the delivery valve holder.
6. Conform that the crankshaft damper pulley notched line is aligned with the timing gear case cover pointer.

Injection Timing (Static BTDC)
17°

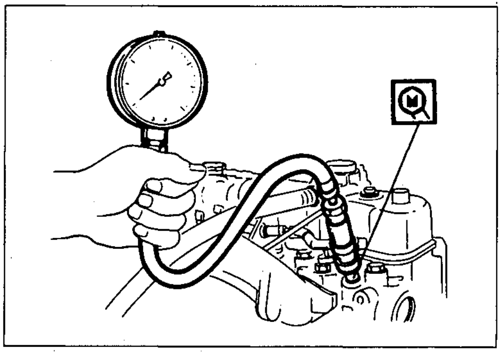


7. Remove the delivery valve holder.
8. Install the delivery valve ①, the delivery valve spring ②, and the delivery valve holder ③.
9. Tighten the delivery valve holder to the specified torque.
10. Install the fuel injection pipes and tighten them to the specified torque.

Fuel Injection Pipe Torque kg·m(lb.ft/N·m)

3.0 ± 1.2 (21.7 ± 8.7/29.4 ± 11.8)

11. Operation to air breeding.



COMPRESSION PRESSURE MEASUREMENT

1. Start the engine and allow it to run for several minutes to warm it up.
2. Stop the engine and cut the fuel supply.
3. Remove all of the glow plugs from the engine.

Compression Gauge: 5-8840-2008-0
Adapter : 5-8531-7001-0

4. Set a comression gauge to the No. 1 cylinder glow plug hole.
5. Turn the engine over with the starter motor and take the compression gauge reading.

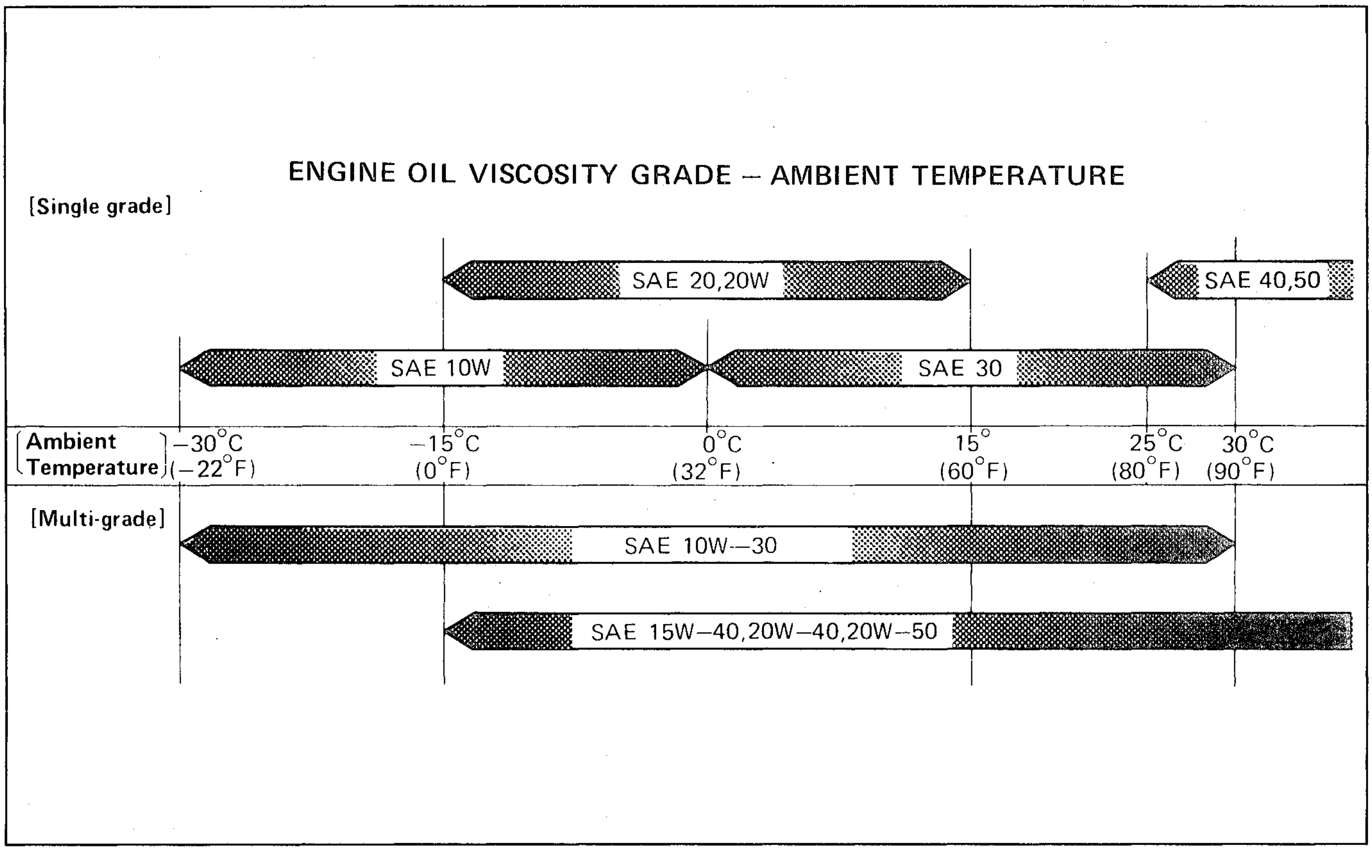
Compression Pressure kg/cm^2(psi/kPa) at 200 rpm

Standard	Limit
31 (441/3,038)	22 (313/2,156)

RECOMMENDED LUBRICANTS

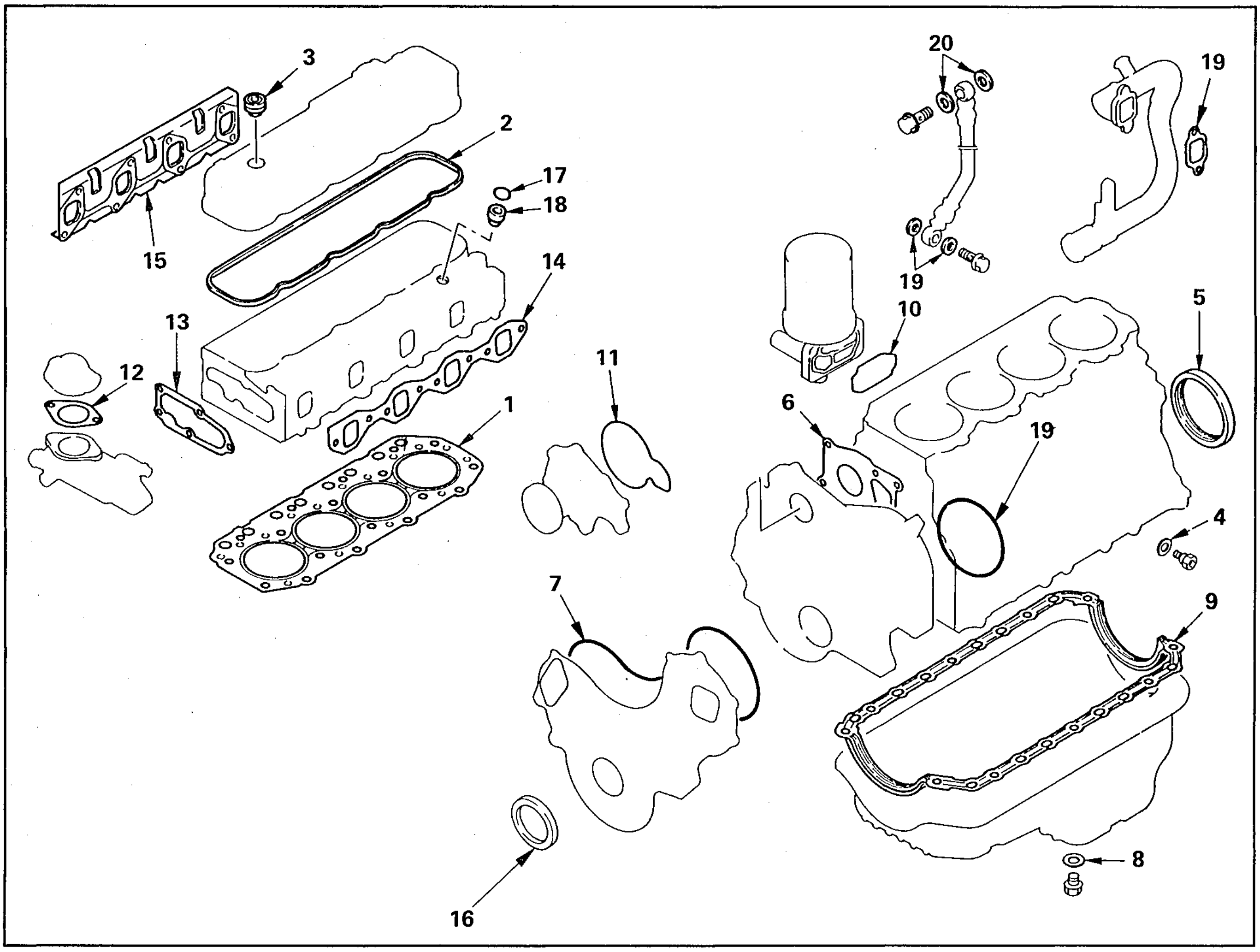
ENGINE TYPE	TYPES OF LUBRICANTS
Without turbocharger	Diesel engine oil CC or CD grade
With turbocharger	Diesel engine oil CD grade

ENGINE OIL VISCOSITY CHART



ENGINE REPAIR KIT

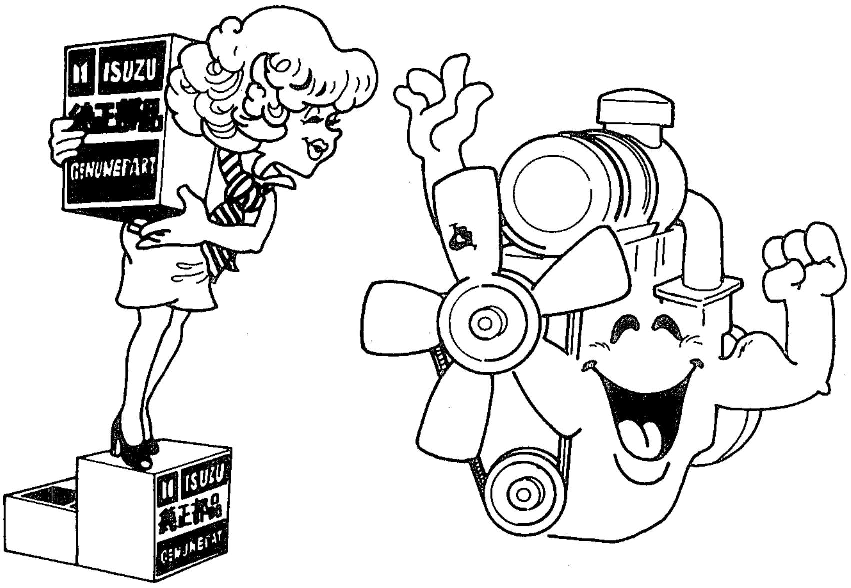
All of the numbered parts listed below are included in the Engine Repair Kit.
The gaskets marked with an asterisk (*) are also included in the Top Overhaul Kit.



* 1. Cylinder head gasket
* 2. Cylinder head cover gasket
* 3. Head cover cap nut gasket
4. Drain cock gasket
5. Crankshaft rear oil seal
6. Gear case gasket
7. Gear case cover gasket
8. Oil pan drain plug gasket
9. Oil pan gasket
10. Oil filter gasket
11. Water pump gasket
12. Water outlet pipe gasket
* 13. Thermostat housing gasket
* 14. Intake manifold gasket
* 15. Exhaust manifold gasket
16. Crankshaft front oil seal
* 17. Nozzle holder O-ring
* 18. Nozzle holder gasket
19. Joint bolt gasket
20. Vacuum pump pipe gasket

MEMO

"QUALITY PARTS YOU CAN TRUST"


ISUZU
純正部品
GENUINE PART
ISUZU
純正部品
GENUINE PART

SECTION 3

ENGINE ASSEMBLY - I

TABLE OF CONTENTS

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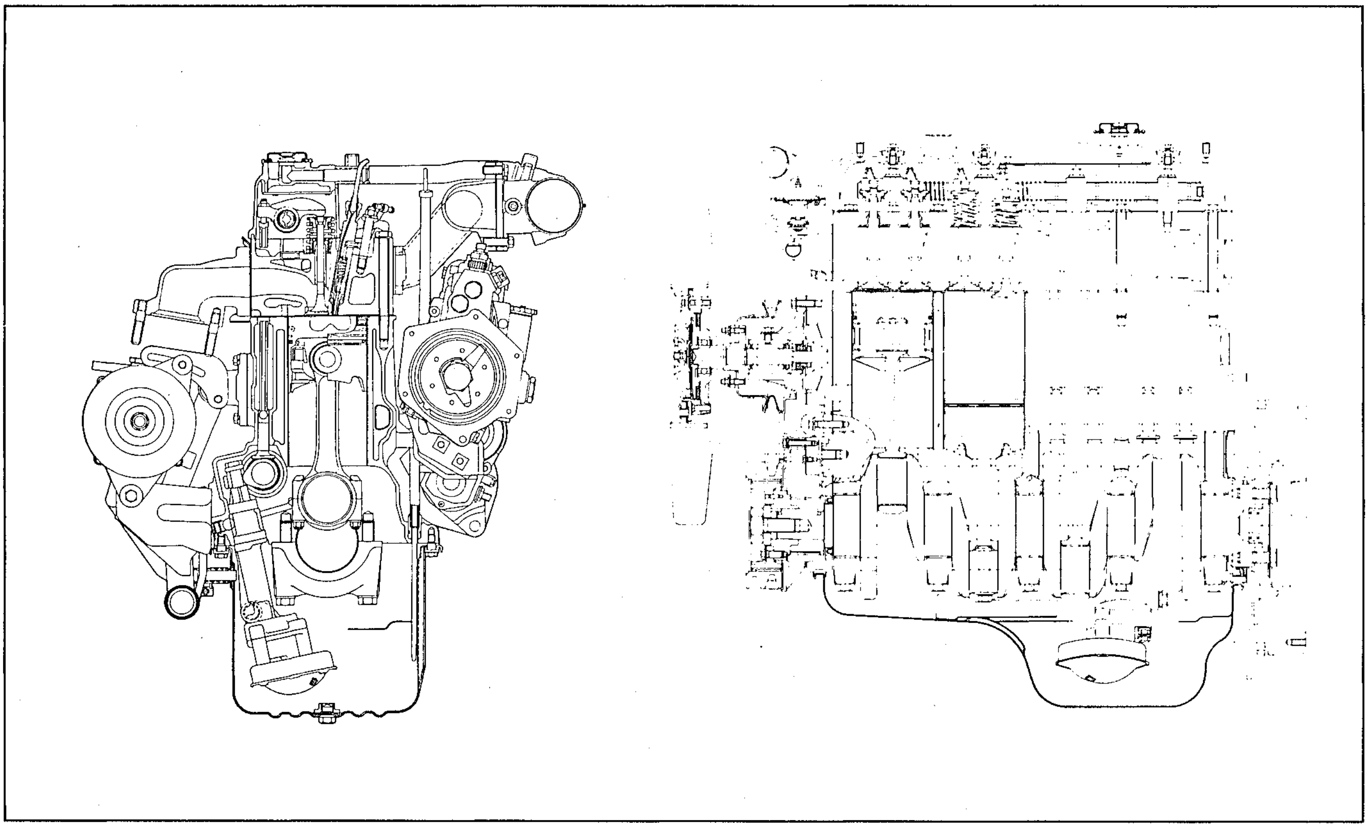
Disassembly .... 3— 3

ENGINE ASSEMBLY

GENERAL DESCRIPTION

This illustration is based on the 4JA1 engine.



The 4J Series of industrial engines features the unique ISUZU troidal square combustion chamber. This design provides superior fuel economy for a wide range.

Auto-thermatic pistons with cast steel struts are used to reduce thermal expansion and resulting engine noise when the engine is cold.

Chrome plated dry type cylinder liners provide the highest durability.

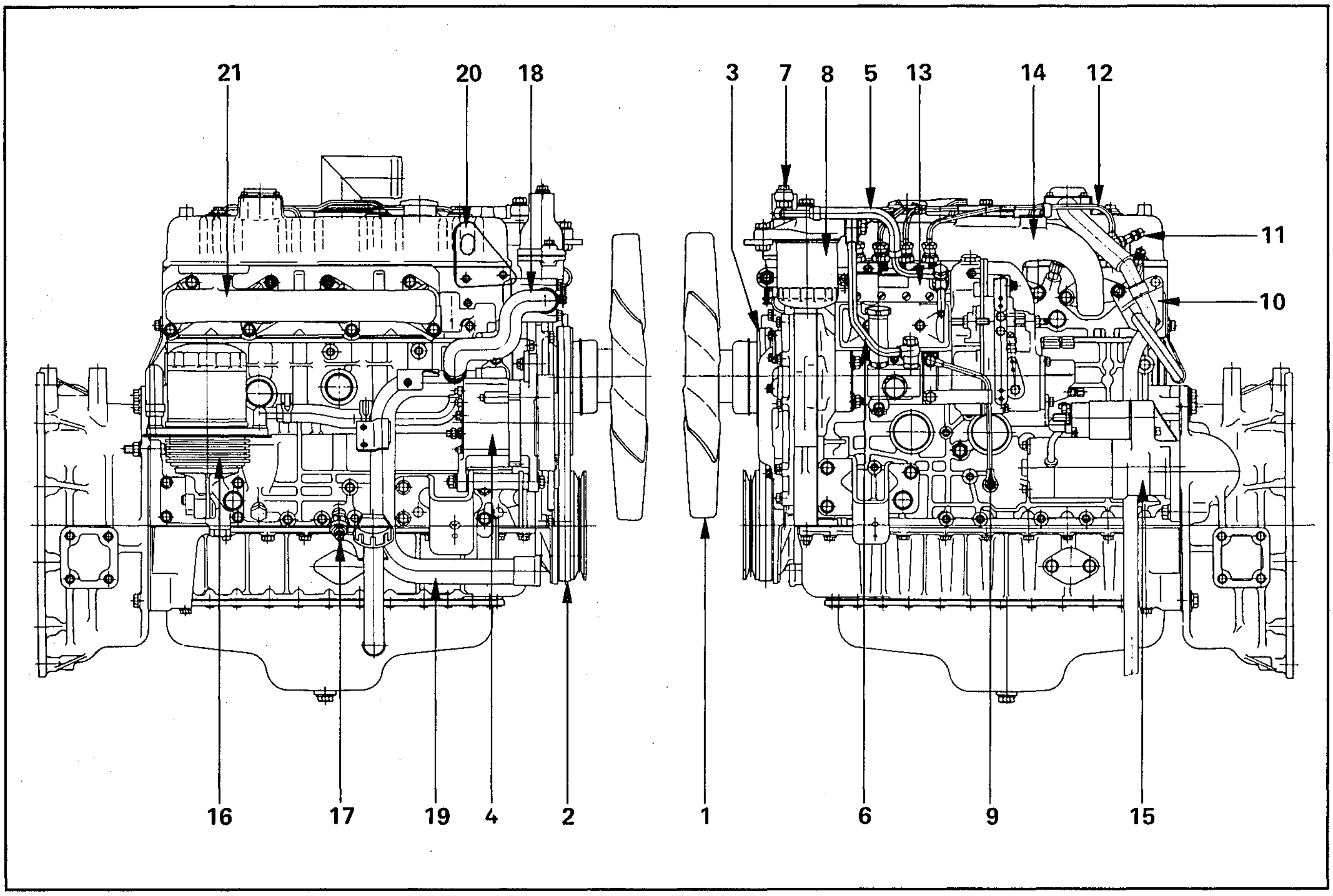
The laminated steel sheet cylinder head gasket is very durable.
This type of gasket eliminates cylinder head bolt retightening.

The tufftrided crankshaft has a long service life. Because it is tufftrided, it cannot be reground.

The crankshaft main bearings and the connecting rod bearings are aluminum plated. These bearings are especially sensitive to foreign material such as metal scraps. It is very important that the oil ports and other related parts be kept clean and free of foreign material.

DISASSEMBLY

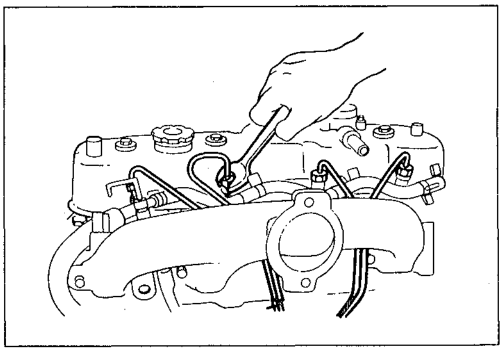
These disassembly steps are based on the 4JA1 engine.



Disassembly Steps - 1

1. Cooling fan and spacer
2. Cooling fan drive belt
3. Cooling fan drive pulley
4. Alternator and adjusting plate
5. Fuel pipe (Fuel filter to injection pump)
6. Fuel pipe (Fuel filter to feed pump)
7. Fuel pipe (Fuel filter leak off)
8. Feul filter
9. Oil pipe (Injection pump to cylinder body)
10. Rear engine hanger
11. Fuel leak off pipe
12. ▲ 12. Fuel injection pipe with clip
13. ▲ 13. Injection pump
14. Intake manifold
15. Starter
16. Oil filter
17. Oil pressure switch
18. Cooling water rubber hose
19. Cooling water intake pipe
20. Front engine hanger
21. ▲ 21. Exhaust manifold

Important Operations (Disassembly Steps - 1)

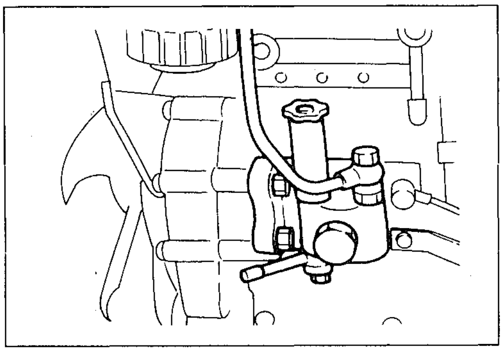


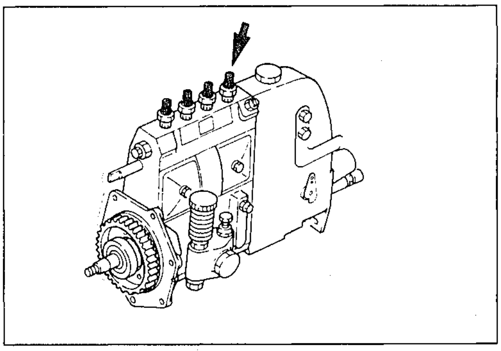
12. Fuel Injection Pipe with Clip

1) Loosen the injection pipe sleeve nuts at the dalivery valve side.

   Do not apply excessive force to the injection pipes.

2) Loosen the injection pipe clips.
3) Remove the injection pipes.



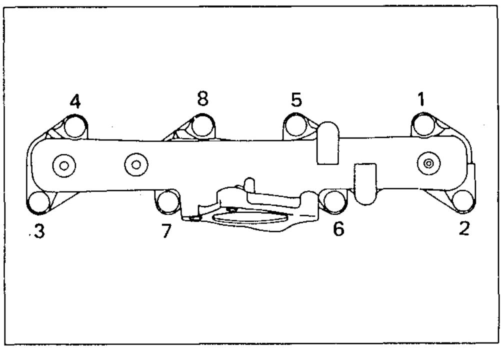


13. Injection Pump

1) Remove the six injection pump bracket bolts from the cylinder body timing gear case.
2) Remove the injection pump rear bracket bolts from the rear bracket.
3) Pull the injection pump with the injection pump timing gear free from the rear.

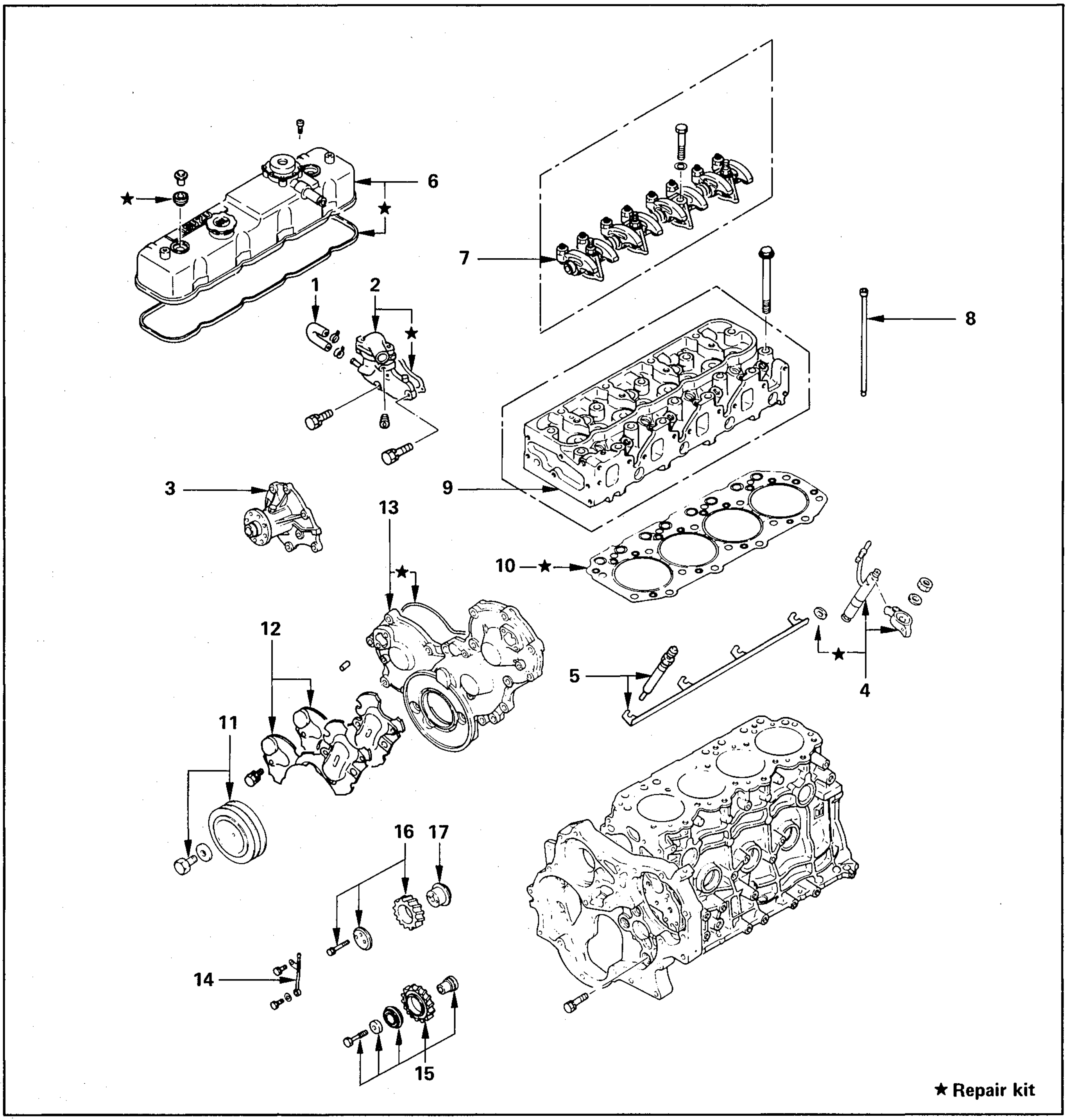
Note:

Plug the injection pump delivery holder ports with the shipping caps (or the equivalent) to prevent the entry of foreign material.



21. Exhaust Manifold

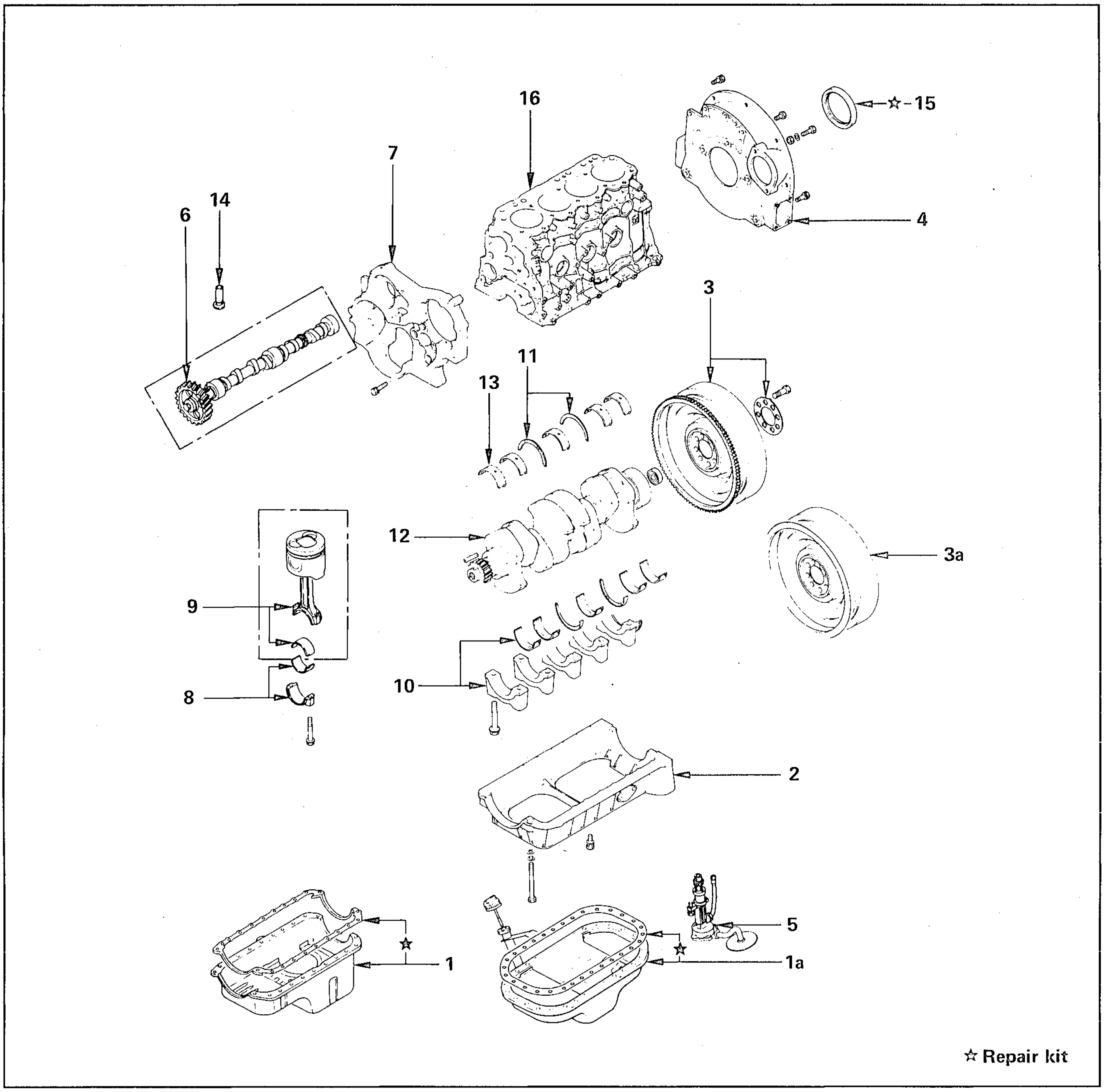
Loosen the exhaust manifold bolts a little at a time in the numerical order shown in the illustration.



Disassembly Steps - 2

1. Water by-pass hose
2. Thermostat housing
3. Water pump
▲ 4. Injection nozzle holder
5. Glow plug and glow plug connector
6. Cylinder head cover
▲ 7. Rocker arm shaft and rocker arm
8. Push rod
▲ 9. Cylinder head
10. Cylinder head gasket
▲ 11. Crankshaft damper pulley with dust seal
12. Timing gear case cover
13. Timing gear cover
14. Timing gear oil pipe
15. Idler gear "B" and shaft
▲ 16. Idler gear "A"
17. Idler gear shaft

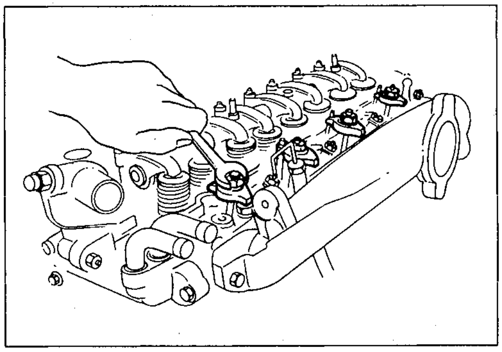
Inverted Engine



Disassembly Steps - 3

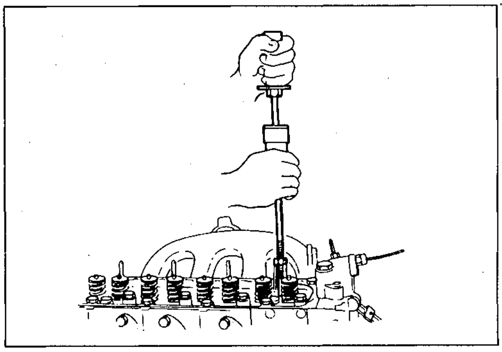
- 1. Oil pan
- 1a. Oil pan (If so crankcase equipped)
- 2. Crankcase (If so equipped)
- ▲ 3. Flywheel
- 3a. Rear flywheel (If so equipped)
- 4. Flywheel housing
- 5. Oil pump with oil pipe
- ▲ 6. Camshaft with camshaft timing gear and thrust plate
- 7. Timing gear case
- ▲ 8. Connecting rod cap with lower bearing
- ▲ 9. Piston and connecting rod with upper bearing
- ▲ 10. Crankshaft bearing cap with lower bearing
- 11. Crankshaft thrust bearing
- 12. Crankshaft with crankshaft timing gear
- ▲ 13. Crankshaft upper bearing
- ▲ 14. Tappet
- 15. Crankshaft rear oil seal
- 16. Cylinder body

Important Operations (Disassembly Steps - 2)



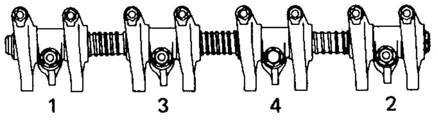
4. Injection Nozzle Holder

1) Remove the nozzle holder bracket nuts.



2) Use the nozzle holder remover and the sliding hammer to remove the nozzle holder together with the holder bracket.

Nozzle Holder Remover: 5-8840-2034-0
Sliding Humme: 5-8840-0019-0

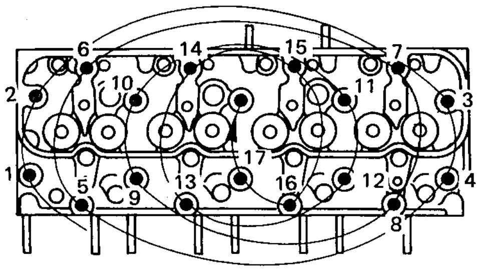


7. Rocker Arm Shaft and Rocker Arm

Loosen the rocker arm shaft bracket bolts in numerical order a little at a time.

Note:

Failure to loosen the rocker arm shaft bracket bolts in numerical order a little at a time will adversely effect the rocker arm shaft.

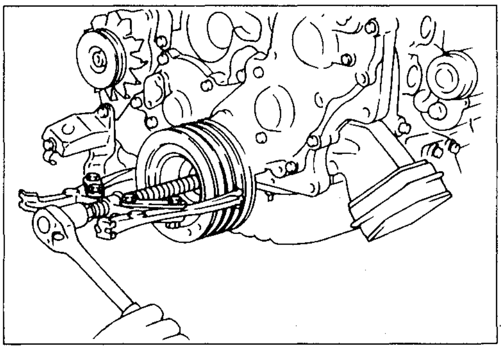


9. Cylinder Head

Loosen the cylinder head bolts in numerical order a little at a time.

Note:

Failure to loosen the cylinder head bolts in numerical order a little at a time will adversely effect the cylinder head lower surface.



11. Crankshaft Damper Pulley with Dust Seal

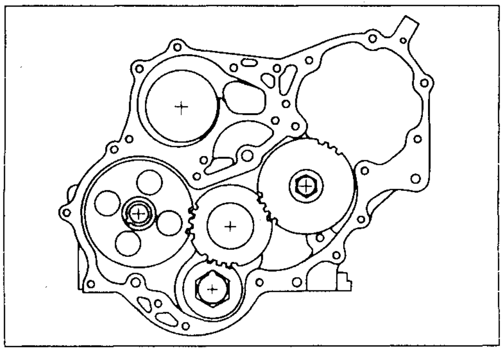
1) Block the flywheel with a piece of wood to prevent it from turning.

2) Use the damper pulley remover to remove the damper pulley.

   Damper Pulley Remover

16. Idler Gear "A"

Measure the camshaft timing gear backlash, the crankshaft timing gear backlash, and the idler gear "A" end play before removing the idler gear "A" and shaft.



Timing Gear Backlash Measurement

1) Set a dial indicator to the timing gear to be measured.

   Hold both the gear to be checked and the adjoining gear stationary.

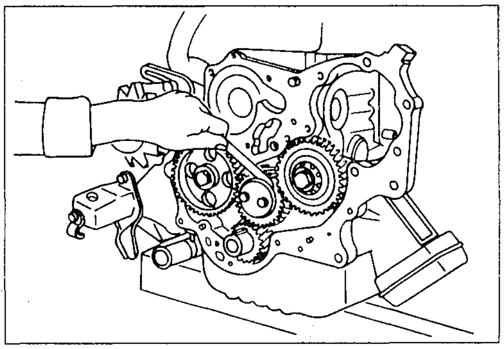
2) Move the gear to be checked as far as possible to both the right and the left.

   Take the dial indicator reading.

   If the measured value exceeds the specified limit, the timing gear must be replaced.

Timing Gear Backlash mm(in.)

Standard	Limit
0.10—0.17 (0.0039—0.0067)	0.30 (0.012)



Idler Gear "A" End Play Measurement

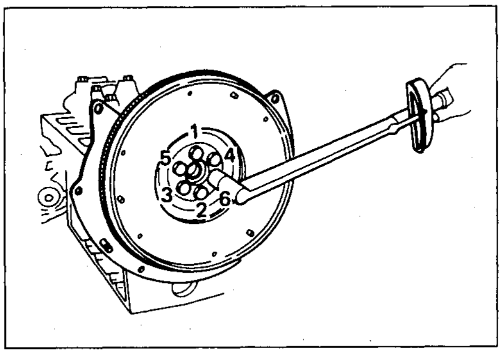
Insert a feeler gauge between the idler gear and the thrust collar to measure the gap and determine the idler gear end play.

If the measured value exceeds the specified limit, the thrust collar must be replaced.

Idler Gear End Play mm(in.)

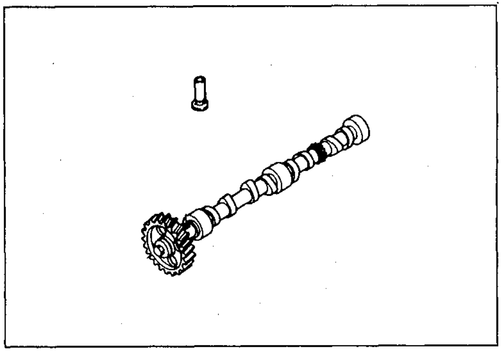
Standard	Limit
0.07 (0.0028)	0.30 (0.012)

Important Operations (Disassembly Steps - 3)



3. Flywheel

1) Block the flywheel with a piece of wood to prevent it from turning.
2) Loosen the flywheel bolts a little at a time in the numerical order shown in the illustration.

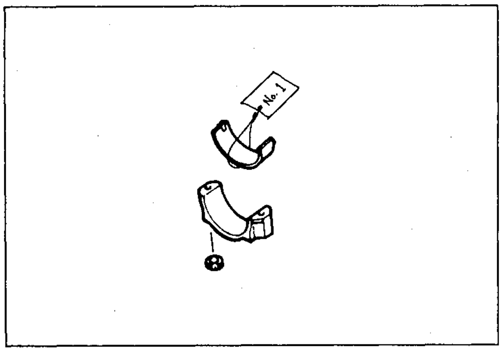


6. Camshaft with Camshaft Timing Gear and Thrust Plate

1) Remove the thrust plate bolts.
2) Pull the camshaft free along with the camshaft timing gear and the thrust plate.

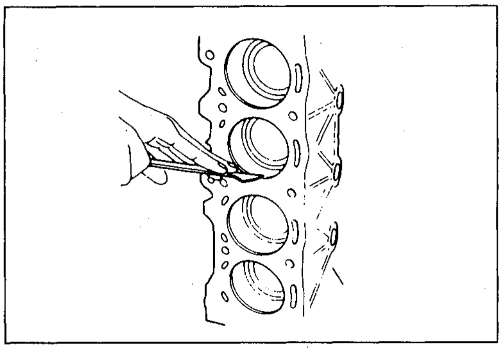
Note:

Be careful not to damage the camshaft journal, the cam, and the camshaft during the disassembly procedure.



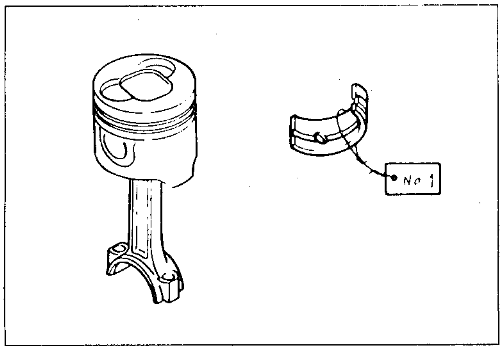
8. Connecting Rod Cap with Lower Bearing

If the connecting rod lower bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.

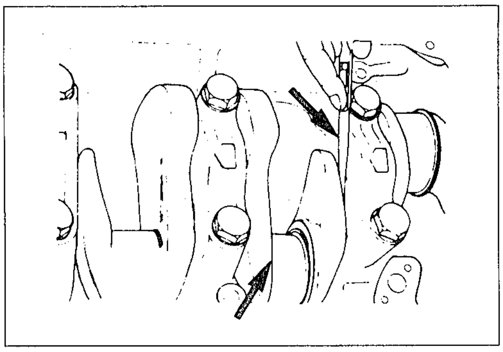


9. Piston and Connecting Rod with Upper Bearing

1) Remove carbon deposits from the upper portion of the cylinder wall with a scraper before removing the piston and connecting rod.
2) Move the piston to the top of the cylinder and tap lit with a hammer grip or similar object from the connecting rod lower side to drive it out.



If the connecting rod upper bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.



10. Crankshaft Bearing Cap with Lower Bearing

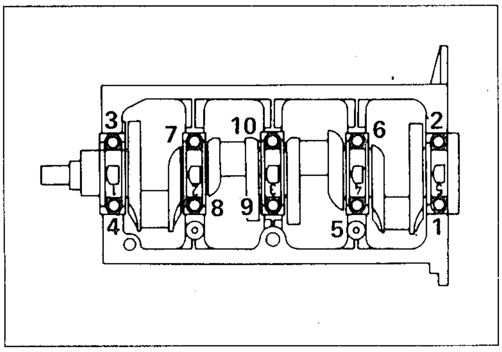
1) Measure the crankshaft end play at the center journal of the crankshaft.

   Do this before removing the crankshaft bearing caps.

   If the measured value exceeds the specified limit, the crankshaft thrust bearing must be replaced.

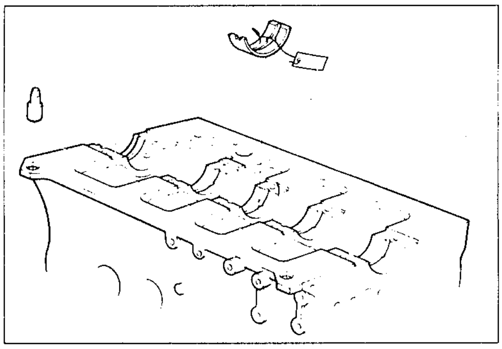
Crankshaft End Play mm(in.)

Standard	Limit
0.10 (0.004)	0.30 (0.012)



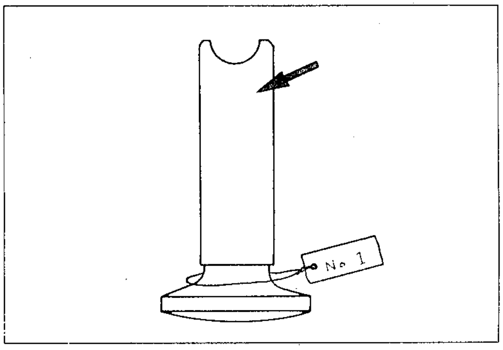
2) Loosen the crankshaft bearing cap bolts in numerical order a little at a time.

   If the crankshaft bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.



13. Crankshaft Upper Bearing

If the crankshaft upper bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.



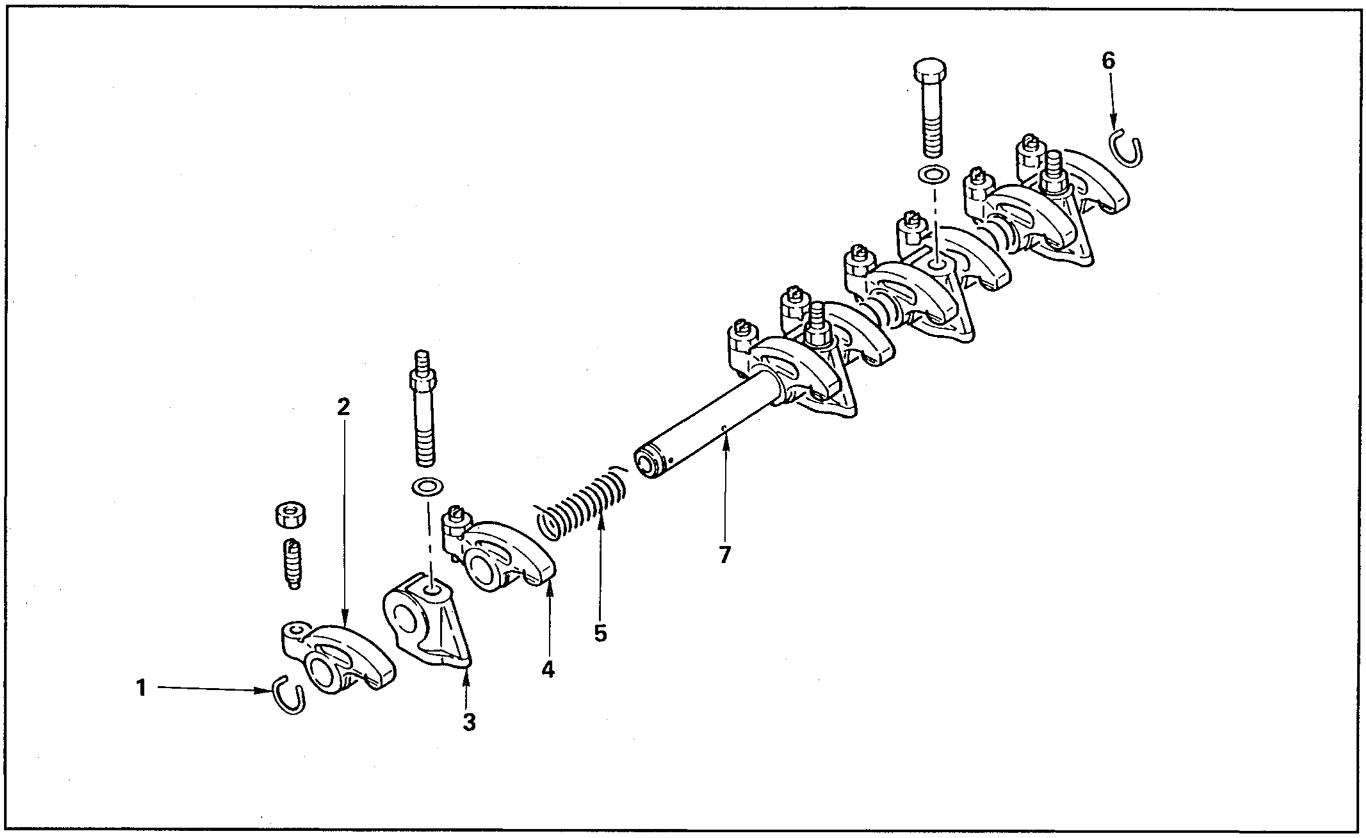
14. Tappet

If the tappets are to be reinstalled, mark their fitting positions by tagging each tappet with the cylinder number from which it was removed.

DISASSEMBLY

SINGLE UNIT

ROCKER ARM SHAFT AND ROCKER ARM



Disassembly Steps

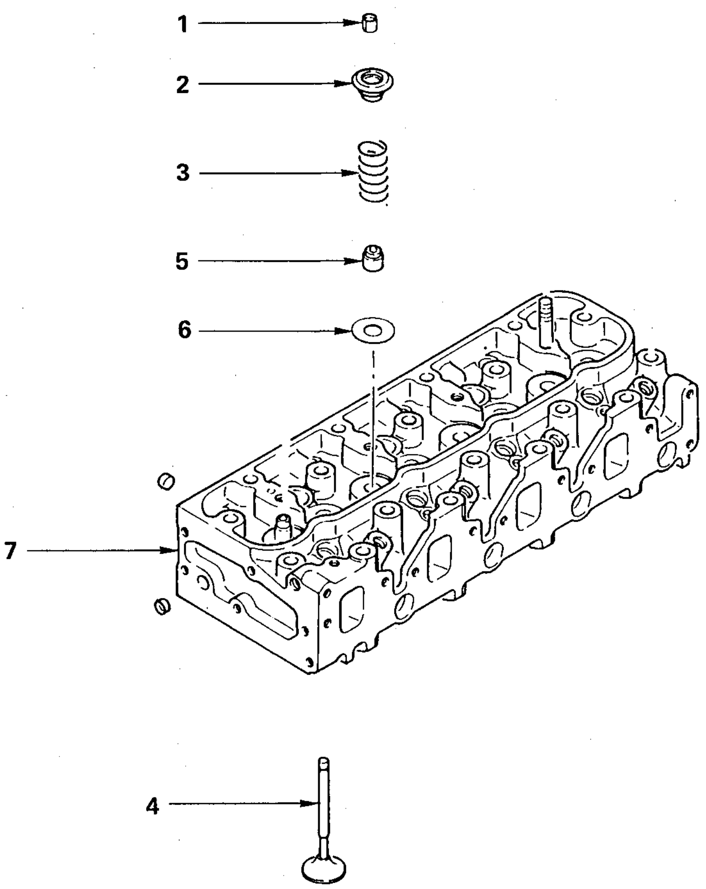
- ▲ 1. Rocker arm shaft snap ring
- ▲ 2. Rocker arm
- ▲ 3. Rocker arm shaft bracket
- 4. Rocker arm
- 5. Rocker arm shaft spring
- 6. Rocker arm shaft snap ring
- 7. Rocker arm shaft

Important Operations

1. **Rocker Arm Shaft Snap Ring**
2. **Rocker Arm**
3. **Rocker Arm Shaft Bracket**
    1) Use a pair of snap ring pliers to remove the snap rings.
    2) Remove the rocker arms.
    3) Remove the rocker arm shaft bracket.

       If the rocker arms and rocker arm shaft brackets are to be reinstalled, mark their installation positions by tagging each rocker arm and rocker arm shaft bracket with the cylinder number from which it was removed.

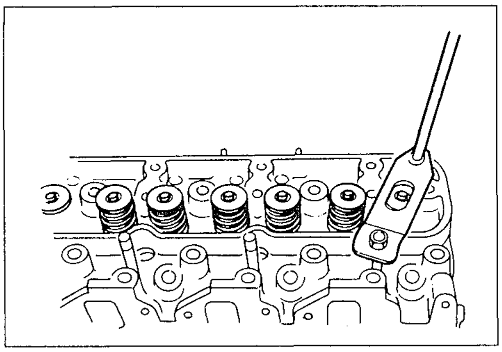
CYLINDER HEAD



Disassembly Steps

- ▲ 1. Split collar
- 2. Valve spring upper seat
- 3. Valve spring
- ▲ 4. Intake and exhaust valves
- 5. Valve stem oil seal
- 6. Valve spring lower washer
- 7. Cylinder head

Important Operations



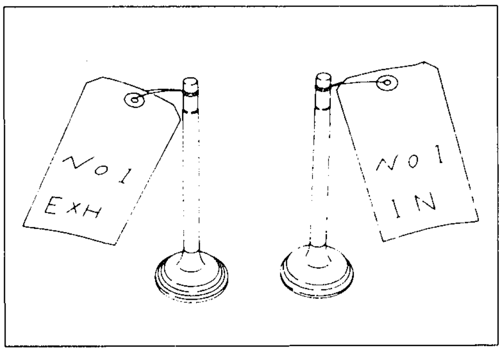
1. Split Collar

1) Place the cylinder head on a flat wooden surface.

2) Use the spring compressor to remove the split collar.

   Do not allow the valve to fall from the cylinder head.

   Spring Compressor: 9-8523-1423-0

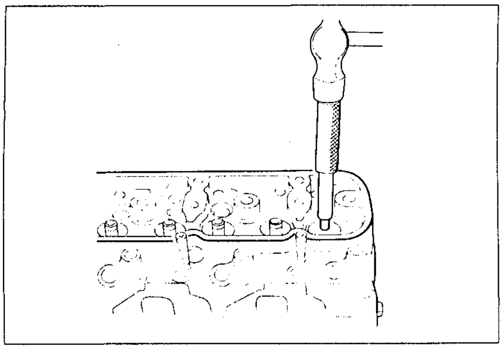


4. Intake and Exhaust Valve

If the intake and exhaust valves are to be reinstalled, mark their installation positions by tagging each valve with the cylinder number from which it was removed.

If there is excessive valve wear or damage, the valve must be replaced.

Refer to Page 4—4 of "Inspection and Repair" for the valve and valve seat insert procedure.



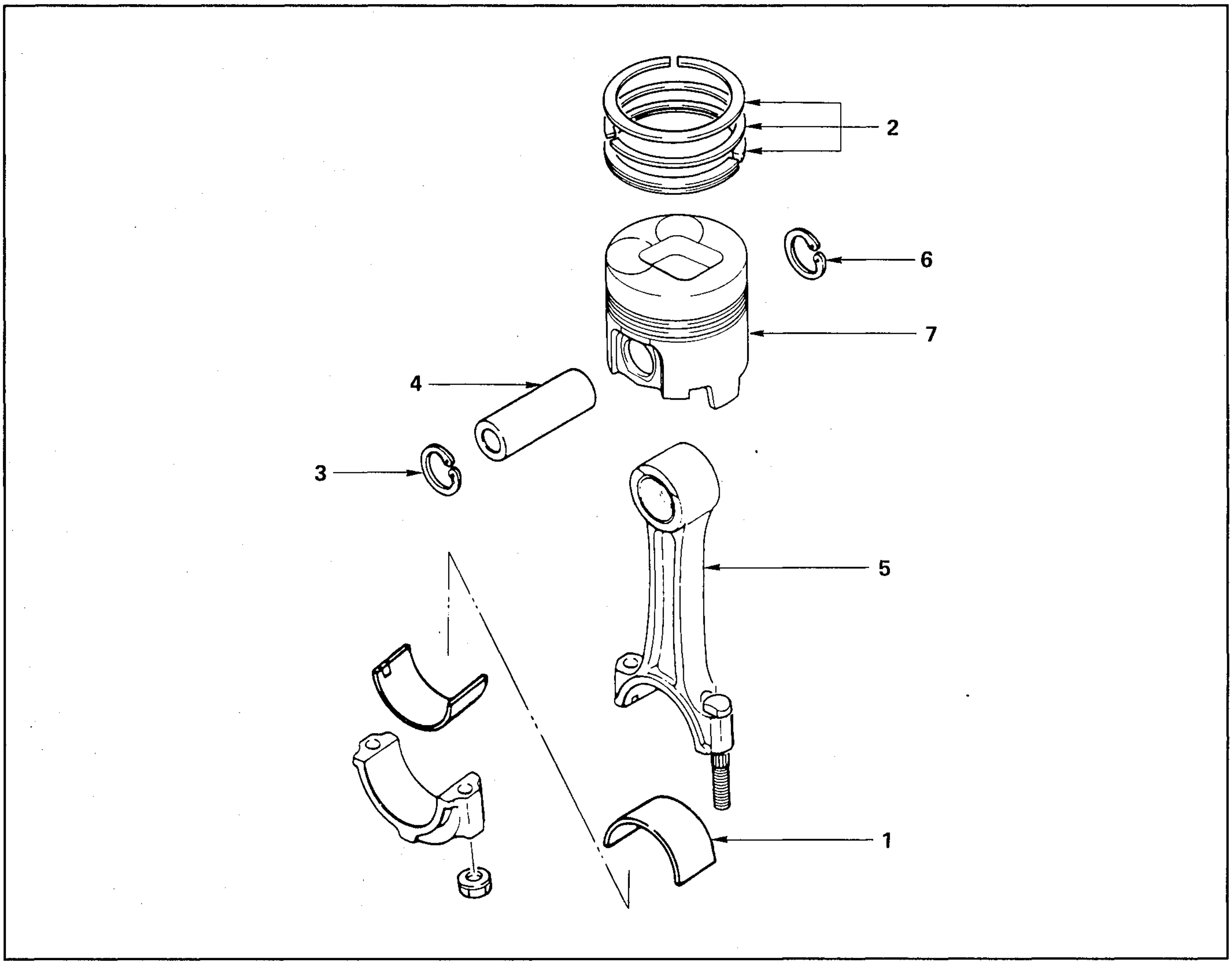
Note:

If there is excessive valve guide wear or damage, the valve guide must be replaced.

Refer to Page 4—3 of "Inspection and Repair" for the valve guide replacement procedure.

The valve and the valve guides must be replaced as a set. Never replace only one or the other.

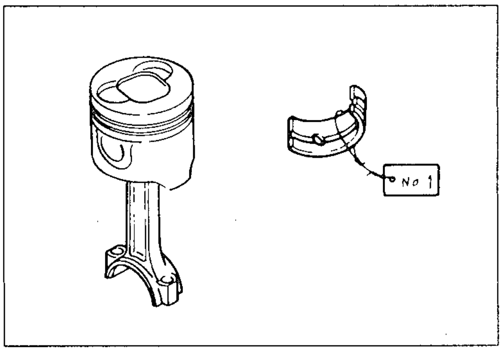
PISTON AND CONNECTING ROD



Disassembly steps

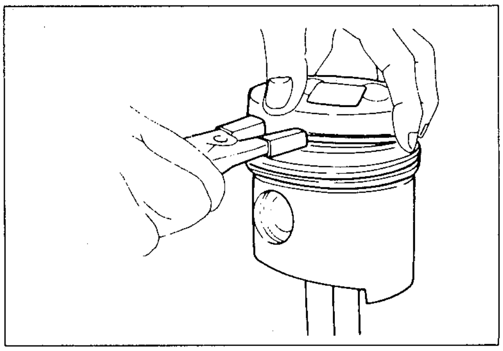
▲ 1. Connecting rod bearing
▲ 2. Piston ring
▲ 3. Piston pin snap ring
▲ 4. Piston pin
5. Connecting rod
▲ 6. Piston pin snap ring
▲ 7. Piston

Important Operations



1. **Connecting Rod Bearing**

   If the connecting rod bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.



2. **Piston Ring**

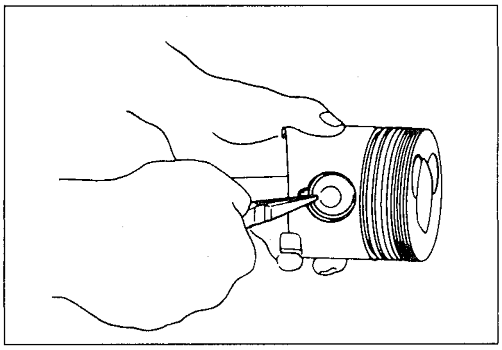
   1) Clamp the connecting rod in a vise.

      Take care not to damge the connecting rod.

   2) Use a piston pin replacer to remove the piston rings.

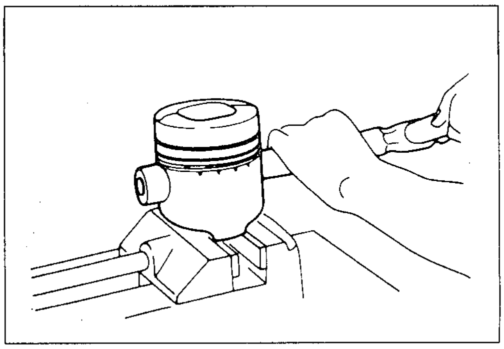
      Piston Ring Replacer

      Do not attempt to use some other tool to remove the piston rings. Piston ring stretching will result in reduced piston ring tension.



3. **Piston Pin Snap Ring**
4. **Piston Pin Snap Ring**

   Use a pair of snap ring pliers to remove the piston pin snap rings.

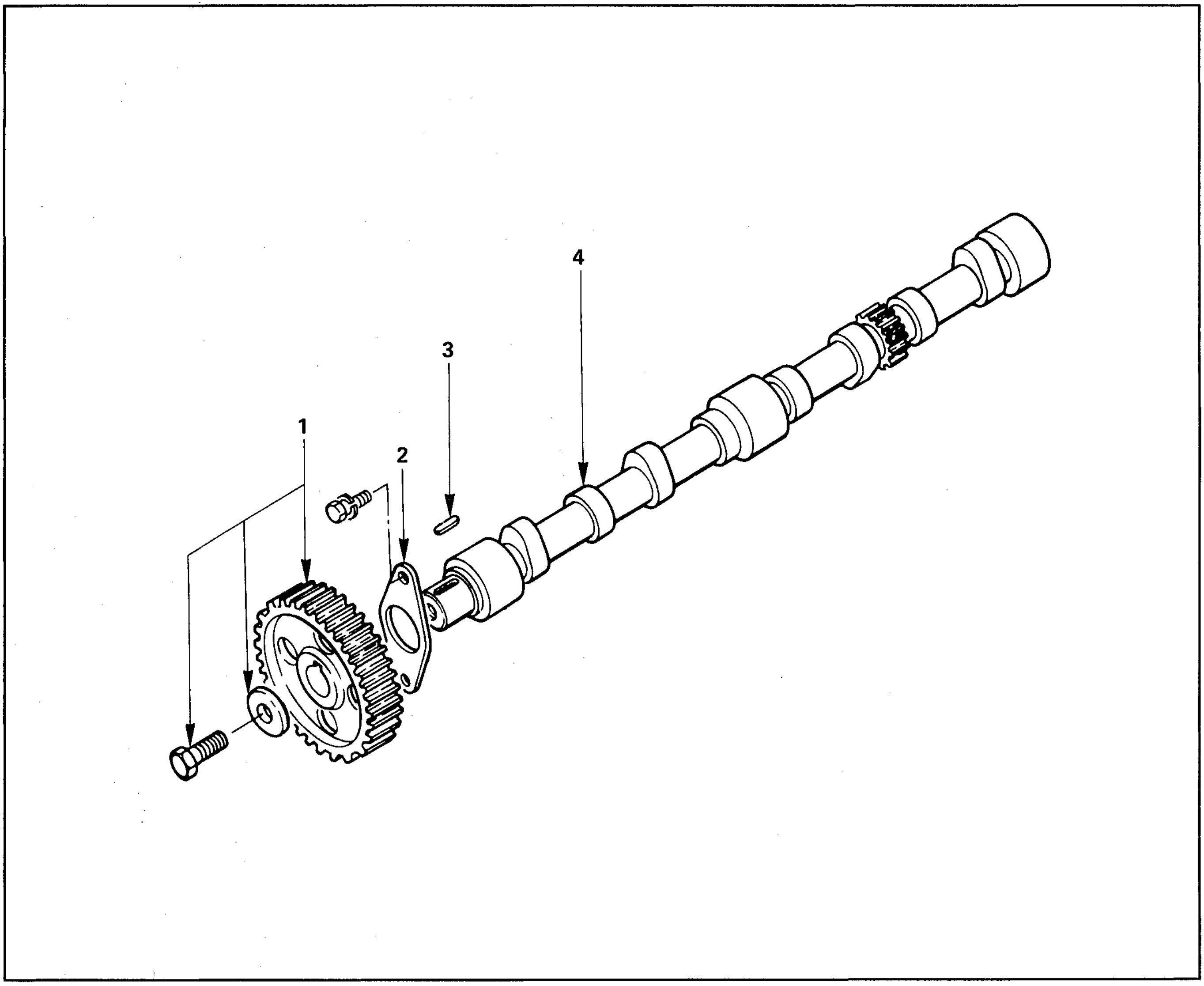


5. **Piston Pin**
7. **Piston**

   Tap the piston pin out with a hammer and a brass bar.

   If the pistons are to be reinstalled, mark their installation positions by tagging each piston with the cylinder number from which it was removed.

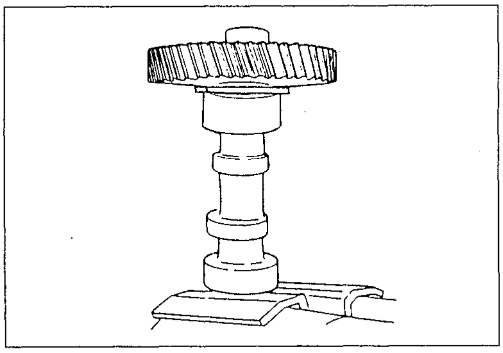
CAMSHAFT, CAMSHAFT TIMING GEAR, AND THRUST PLATE



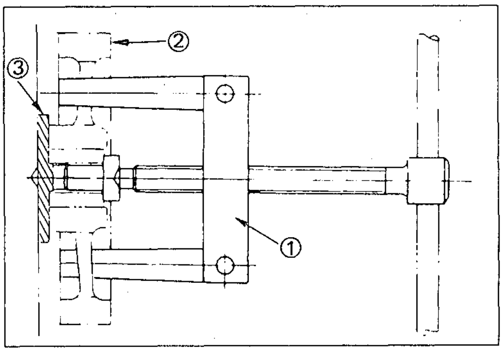
Disassembly Steps

▲ 1. Camshaft timing gear	3. Feather key
▲ 2. Thrust plate	4. Camshaft

Important Operations



1. **Camshaft Timing Gear**
2. **Thrust Plate**
   1) Clamp the camshaft in a vise.
   Take care not to damage the camshaft.



2) Use the universal puller ① to pull out the camshaft timing gear ②.

   Universal Puller: 5-8840-0086-0

3) Remove the thrust plate ③.

SECTION 4

ENGINE ASSEMBLY — II

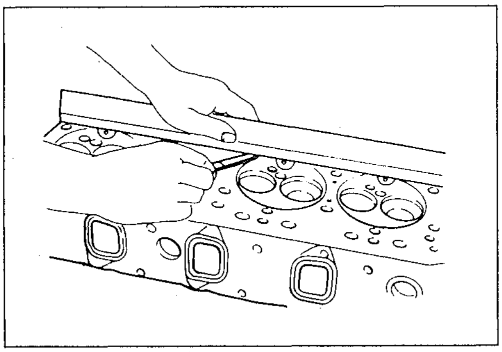
TABLE OF CONTENTS

ITEM **PAGE**

Inspection and repair .... 4— 1

INSPECTION AND REPAIR

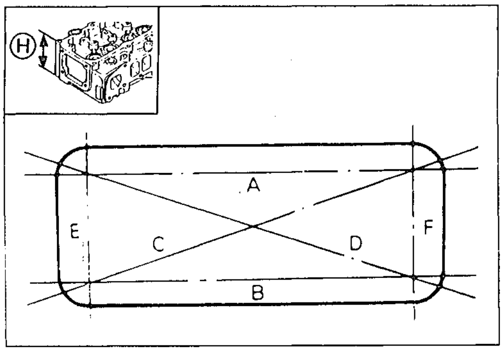
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



CYLINDER HEAD

Cylinder Head Lower Face Warpage

1. Use a straight edge and a feeler gauge to measure the four sides and the two diagonals of the cylinder head lower face.
2. Regrind the cylinder head lower face if the measured values are greater than the specified limit but less than the maximum grinding allowance.



If the measured values exceed the maximum grinding allowance, the cylinder head must be replaced.

Cylinder Head Lower Face Warpage mm(in)

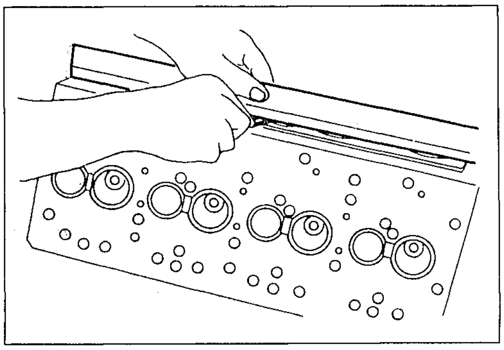
Standard	Limit	Maximum Grinding Allowance
0.05 (0.002) or less	0.2 (0.008)	0.3 (0.012)

Cylinder Head Height (Reference) mm(in)

Standard	Limit
91.95 (3.620) – 92.05 (3.624)	91.65 (3.60)

Note:

If the cylinder head lower face is reground, valve depression must be checked.



Exhaust Manifold Fitting Face Warpage

Use a straight edge and a feeler gauge to measure the manifold cylinder head fitting face warpage.

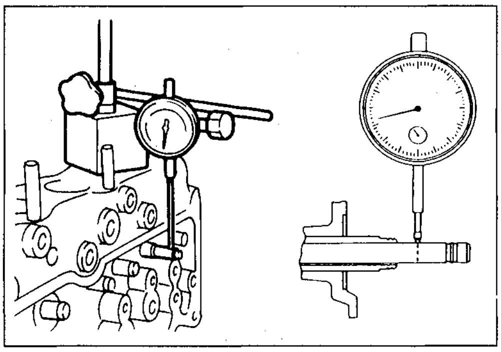
Regrind the manifold cylinder head fitting faces if the measured values are greater than the specified limit but less than the maximum grinding allowance.

If the measured values exceed the maximum grinding allowance, the cylinder head must be replaced.

Manifold Fitting Face Warpage mm(in)

Standard	Limit	Maximum Grinding Allowance
0.05 (0.002) or less	0.2 (0.008)	0.4 (0.016)

VALVE GUIDE



Valve Stem and Valve Guide Clearance

Measuring Method - I

1. With the valve stem inserted in the valve guide, set the dial indicator needle to "0".
2. Move the valve head from side to side.

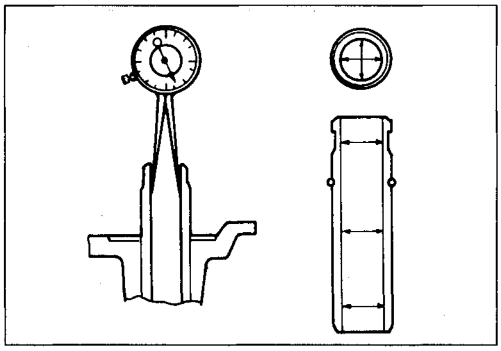
   Read the dial indicator.

   Note the highest dial indication.

   If the measured values exceed the specified limit, the valve and the valve guide must be replaced as a set.

Valve Stem Clearance mm(in)

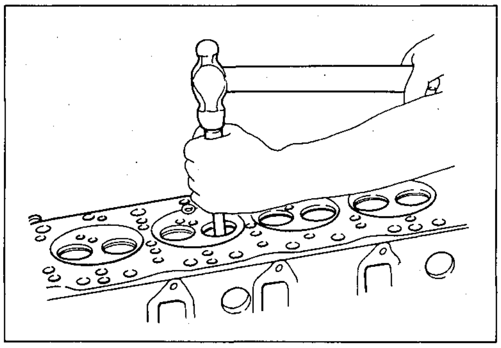
	Standard	Limit
Intake Valve	0.039 — 0.069 (0.0015 — 0.0027)	0.20 (0.008)
Exhaust Valve	0.064 — 0.093 (0.0025 — 0.0037)	0.25 (0.0098)



Measuring Method - II

1. Measure the valve stem outside diameter.

   Refer to the Item "Valve Stem Outside Diameter".
2. Use a caliper calibrator or a telescoping gauge to measure the valve guide inside diameter.

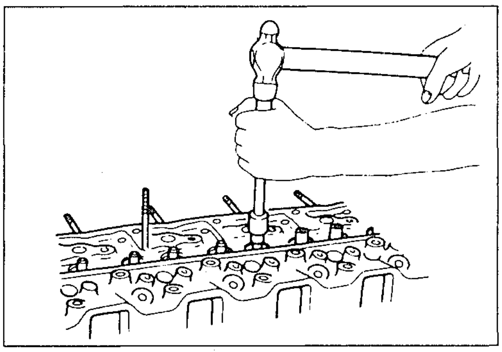


Valve Guide Replacement

Valve Guide Removal

Use a hammer and the valve guide replacer to drive out the valve guide from the cylinder head lower face.

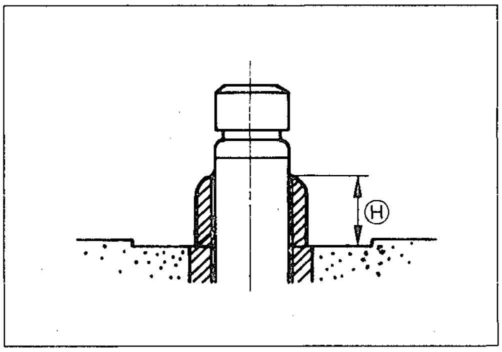
Valve Guide Replacer: 9-8523-1212-0



Valve Guide Installation

1. Apply engine oil to the valve guide outer circumference.
2. Attach the valve guide replacer to the valve guide.
3. Use a hammer to drive the valve guide into position from the cylinder head upper face.

   Valve Guide Replacer: 9-8523-1212-0



4. Measure the height of the valve guide upper end from the upper face of the cylinder head.

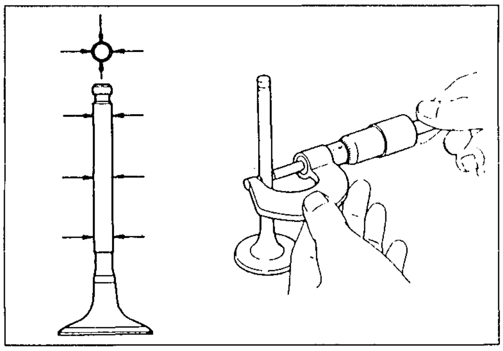
Valve Guide Upper End Height (H)
(Reference) mm(in)

13.0 (0.51)

Note:

If the valve guide has been removed, both the valve and the valve guide must be replaced as a set.

VALVE AND VALVE SEAT INSERT



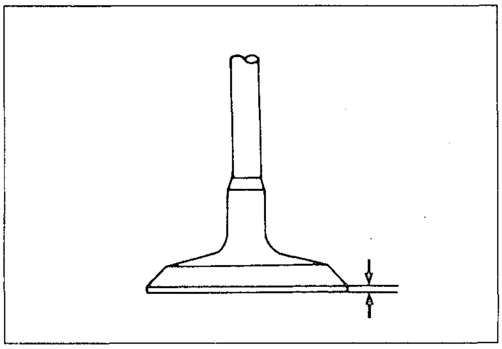
Valve Stem Outside Diameter

Measure the valve stem diameter at three points.

If the measured value is less than the specified limit, the valve and the valve guide must be replaced as a set.

Valve Stem Outside Diameter mm(in)

	Standard	Limit
Intake Valve	7.949 – 7.961 (0.3129 – 0.3134)	7.88 (0.3102)
Exhaust Valve	7.921 – 7.936 (0.3118 – 0.3124)	7.88 (0.3102)



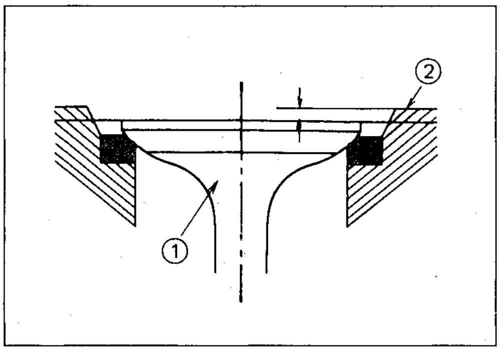
Valve Thickness

Measure the valve thickness.

If the measured value is less than the specified limit, the valve and the valve guide must be replaced as a set.

Intake and Exhaust Valve Thickness mm(in)

Standard	Limit
1.8 (0.07)	1.5 (0.06)



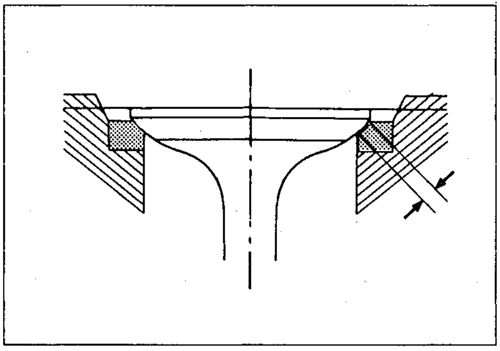
Valve Depression

1. Install the valve ① to the cylinder head ②.
2. Use a depth gauge or a straight edge with steel rule to measure the valve depression from the cylinder head lower surface.

   If the measured value exceeds the specified limit, the valve seat insert must be replaced.

Valve Depression mm(in)

	Standard	Limit
Intake	0.73 (0.029)	1.28 (0.050)
Exhaust	0.70 (0.028)	1.20 (0.047)



Valve Contact Width

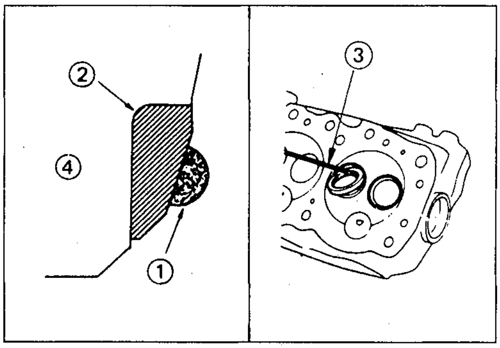
1. Check the valve contact faces for roughness and unevenness.

   Make smooth the valve contact surfaces.
2. Measure the valve contact width.

   If the measured value exceeds the specified limit, the valve seat insert must be replaced.

Valve Contact Width mm(in)

	Standard	Limit
Intake	1.7 (0.067)	2.2 (0.087)
Exhaust	2.0 (0.079)	2.5 (0.078)



Valve Seat Insert Replacement

Valve Seat Insert Removal

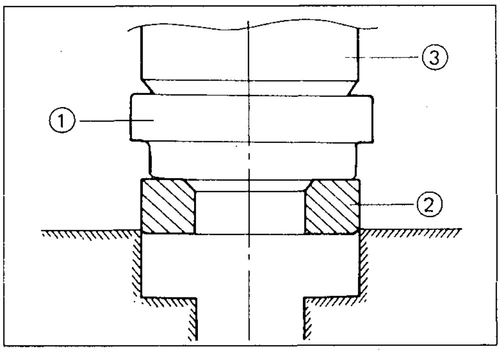
1. Arc weld the entire inside circumference ① of the valve seat insert ②.
2. Allow the valve seat insert to cool for a few minutes.

   This will invite contraction and make removal of the valve seat insert easier.

3. Use a screwdriver ③ to pry the valve seat insert free.

   Take care not to damage the cylinder head ④.

4. Carefully remove carbon and other foreign material from the cylinder head insert bore.



Valve Seat Insert Installation

1. Carefully place the attachment ① (having a smaller outside diameter than the valve seat insert) on the valve seat insert ②.

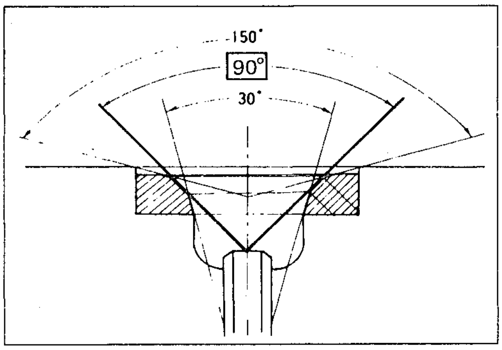
Note:

The smooth side of the attachment must contact the valve seat insert.

2. Use a bench press ③ to gradually apply pressure to the attachment and press the valve seat insert into place.

Note:

Do not apply an excessive amount of pressure with the bench press. Damage to the valve seat insert will result.



Valve Seat Insert Correction

1. Remove the carbon from the valve seat insert surface.
2. Use a valve cutter (15°, 45°, and 75° blades) to minimize scratches and other rough areas. This will bring the contact width back to the standard value.

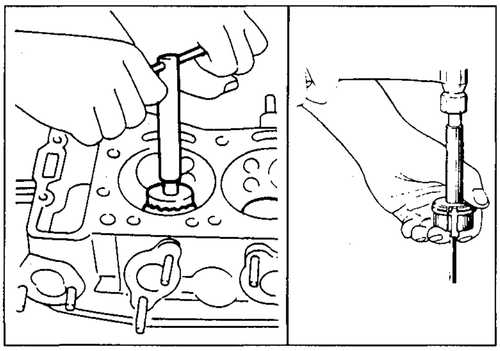
   Remove only the scratches and rough areas. Do not cut away too much. Take care not to cut away unblemished areas of the valve seat surface.

Valve Seat Angle	45°

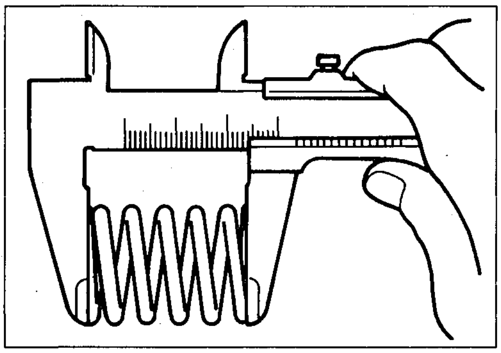
Note:

Use an adjustable valve cutter pilot.

Do not allow the valve cutter pilot to wobble inside the valve guide.



3. Apply abrasive compound to the valve seat insert surface.
4. Insert the valve into the valve guide.
5. Turn the valve while tapping it to fit the valve seat insert.
6. Check that the valve contact width is correct.
7. Check that the valve seat insert surface is in contact with the entire circumference of the valve.



VALVE SPRING

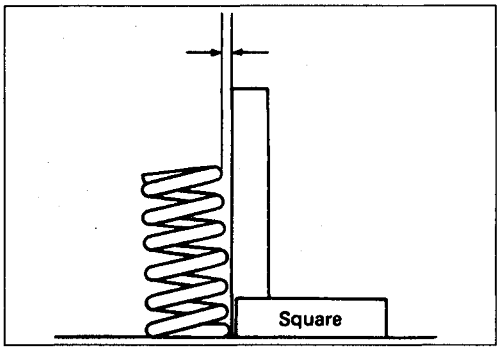
Valve Spring Free Height

Use a vernier caliper to measure the valve spring free height.

If the measured value is less than the specified limit, the valve spring must be replaced.

Valve Spring Free Height mm(in)

Standard	Limit
49.7 (1.96)	48.2 (1.90)



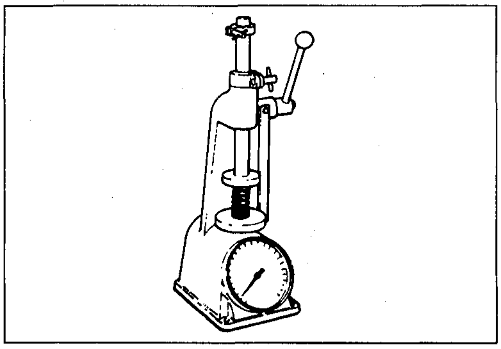
Valve Spring Inclination

Use a surface plate and a square to measure the valve spring inclination.

If the measured value exceeds the specified limit, the valve spring must be replaced.

Valve Spring Inclination mm(in)

Standard	Limit
1.5 (0.06) or less	2.5 (0.984) or more



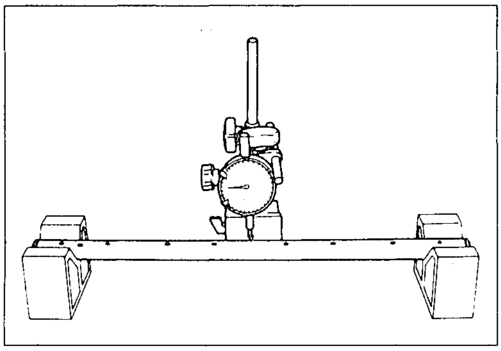
Valve Spring Tension

Use a spring tester to measure the valve spring tension.

If the measured value is less than the specified limit, the valve spring must be replace.

Valve Spring Tension kg(lb)

Compressed Height	Standard	Limit
38.9 mm (1.53 in)	32.6 (71.7)	29.0 (63.8)



ROCKER ARM SHAFT AND ROCKER ARM

Rocker Arm Shaft Run-Out

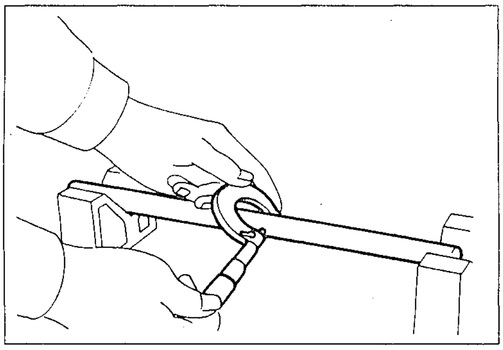
1. Place the rocker arm shaft on a V-block.
2. Use a dial indicator to measure the rocker arm shaft central portion run-out.

   If the run-out is very slight, correct the rocker arm shaft run-out with a bench press. The rocker arm must be at cold condition.

   If the measured rocker arm shaft run-out exceeds the specified limit, the rocker arm shaft must be replaced.

Rocker Arm Shaft Run-Out mm(in)

Standard	Limit
0.2 (0.008)	0.6 (0.0024)



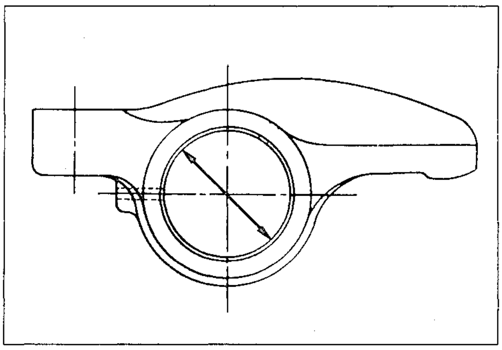
Rocker Arm Shaft Outside Diameter

Use a micrometer to measure the rocker arm fitting portion outside diameter.

If the measured value is less than the specified limit, the rocker arm shaft must be replaced.

Rocker Arm Shaft Outside Diameter mm(in)

Standard	Limit
18.98 — 19.00 (0.747 — 0.748)	18.85 (0.742)



Rocker Arm Shaft and Rocker Arm Clearance

1. Use either a vernier caliper or a dial indicator to measure the rocker arm bushing inside diameter.

Rocker Arm Bushing Inside Diameter mm(in)

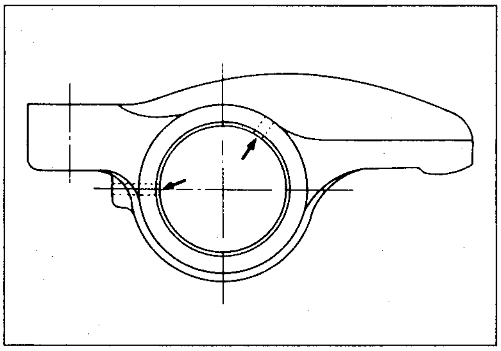
Standard	Limit
19.01 — 19.03 (0.748 — 0.749)	19.05 (0.750)

2. Measure the rocker arm shaft outside diameter.

   If the measured value exceeds the specified limit, replace either the rocker arm or the rocker arm shaft.

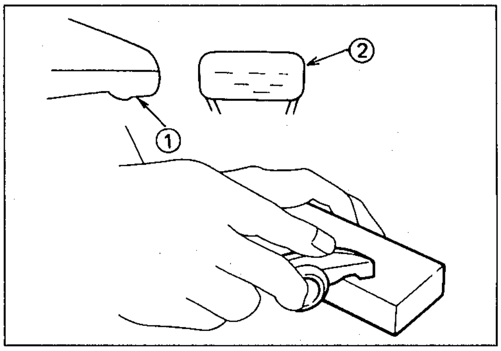
Rocker Arm and Rocker Arm Shaft Clearance mm(in)

Standard	Limit
0.01 — 0.05 (0.0004 — 0.002)	0.2 (0.008)



3. Check that the rocker arm oil port is free of obstructions.

   If necessary, use compressed air to clean the rocker arm oil port.



Rocker Arm Correction

Inspect the rocker arm valve stem contact surfaces for step wear ① and scoring ②.

If the contact surfaces have light step wear or scoring, they may be honed with an oil stone.

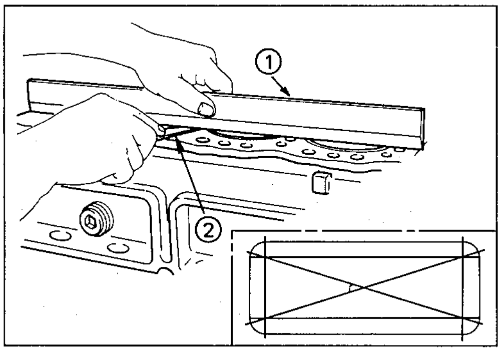
If the step wear or scoring is severe, the rocker arm must be replaced.

CYLINDER BODY

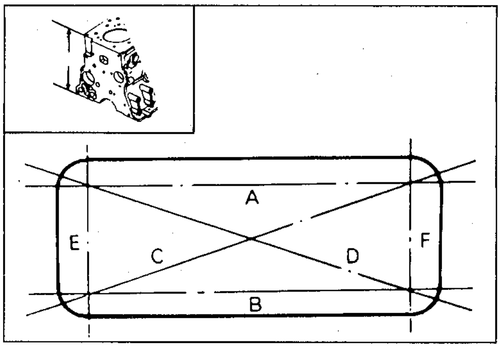
Cylinder Body Upper Face Warpage

1. Remove the cylinder body dowel.
2. Remove the cylinder liner.

   Refer to "Cylinder Liner Replacement".



3. Use a straight edge ① and a feeler gauge ② to measure the four sides and the two diagonals of the cylinder body upper face.



Cylinder Body Upper Face Warpage mm(in)

Standard	Limit
0.05 (0.002) or less	0.2 (0.008)

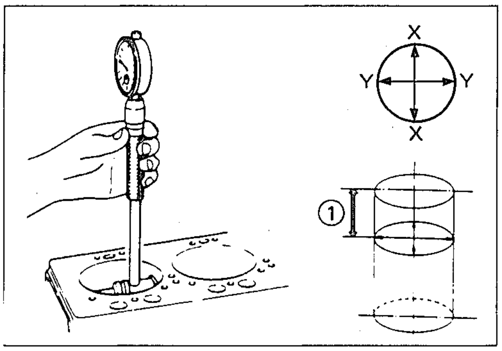
If the measured value is more than the limit, the cylinder body must be replaced.

Cylinder Body Height (Reference) mm(in)

	Standard
4JA1, 4JC1	247.945 — 248.105 (9.7616 — 9.7679)
4JB1	272.945 — 273.105 (10.7458 — 10.7521)

4. Reinstall the cylinder liner.

   Refer to "Cylinder Body Bore Measurement".
5. Reinstall the cylinder body dowel.



Cylinder Liner Bore Measurement

Use a cylinder indicator to measure the cylinder bore at measuring point ① in the thrust X — X and axial Y — Y directions of the crankshaft.

Measuring Point ①: Maximum wear portion
[11 ~ 15 mm (0.43 ~ 0.59 in)]

If the measured value exceeds the specified limit, the cylinder liner must be replaced.

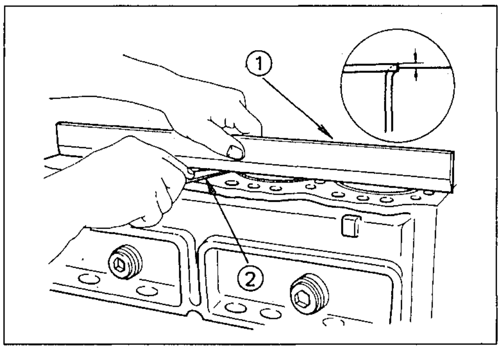
Cylinder Liner Bore mm(in)

	Standard	Limit
4JA1 4JB1	93.021 — 93.060 (3.662 — 3.663)	93.10 (3.665)
4JC1	87.991 — 88.030 (3.464 — 3.466)	88.10 (3.468)

Note:

The inside of the dry type cylinder liner is chrome plated. It cannot be rebored or honed.

If the inside of the cylinder liner is scored or scorched, the cylinder liner must be replaced.



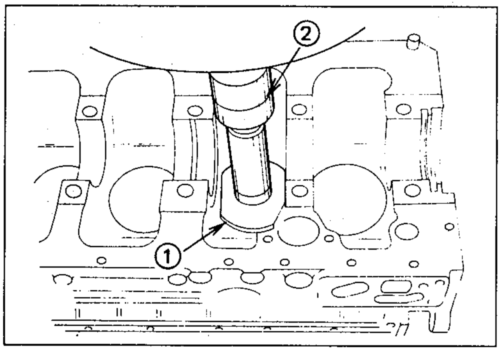
Cylinder Liner Projection Inspection

1. Hold a straight edge ① along the top edge of the cylinder liner to be measured.
2. Use a feeler gauge ② to measure each cylinder liner projection.

Cylinder Liner Projection mm(in)

Standard
0 — 0.10 (0 — 0.004)

The difference in the cylinder liner projection height between any two adjacent cylinders must not exceed 0.03 mm (0.0012 in).



Cylinder Liner Replacement

Cylinder Liner Removal

1. Insert the cylinder liner remover ① into the cylinder body (from the lower side of the cylinder body) unit it makes firm contact with the cylinder liner.

   Cylinder Liner Remover: 5-8840-2039-0 (4JA1, 4JB1)
   5-8840-9021-0 (4JC1)

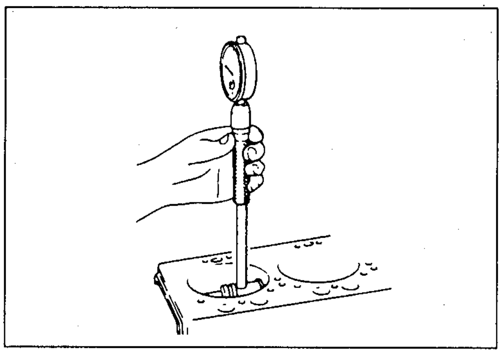
2. Use a bench press ② to slowly force the cylinder liner from the cylinder body.

Note:

Take care not to damage the cylinder body upper face during the cylinder liner removal procedure.

3. Measure the cylinder body upper face warpage.

   Refer to "Cylinder Body Upper Face Warapage".



Cylinder Liner Grade Selection

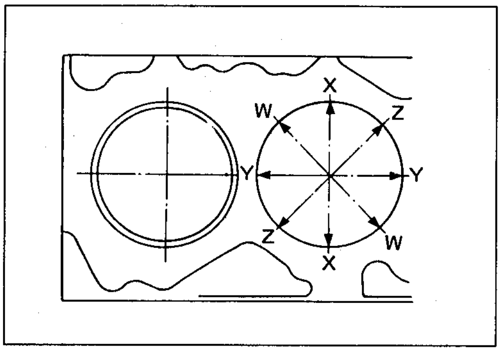
Measure the cylinder body inside diameter and select the appropriate cylinder liner grade.

Standard Fitting Interference mm(in)
0.001 — 0.020 (0.0004 — 0.0078)

If the cylinder liner fitting interference is too small, engine cooling efficiency will be adversely affected.

If the cylinder liner fitting interference is too large, it will be difficult to insert the cylinder liner into the cylinder body.

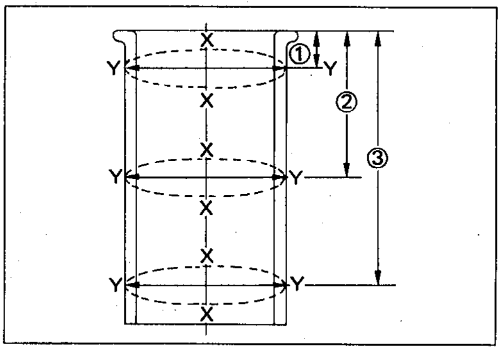
Cylinder Body Bore Measurement



1. Take measurements at measuring point ① across positions ("W — W"), ("X — X"), (Y — Y) and (Z — Z).

Measuring Point ①: 98 mm (3.86 in)

2. Calculate the average value of the four measurements to determine the correct cylinder grade.



Cylinder Liner Outside Diameter Measurement

1. Take two measurements each at measuring points ①, ②, and ③.

Measuring Point ①: 20 mm (0.79 in) all 4J models
Measuring Point ②: 80 mm (3.15 in) 4JA1, 4JC1
90 mm (3.54 in) 4JB1
Measuring Point ③: 140 mm (5.50 in) 4JA1, 4JC1
160 mm (6.30 in) 4JB1

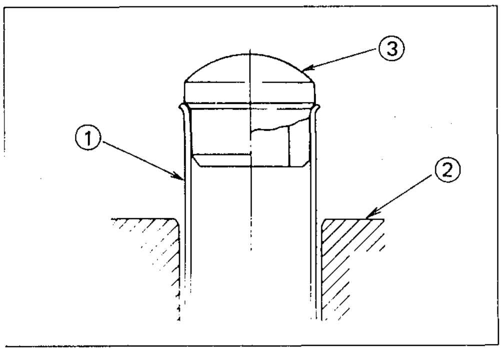
2. Calculate the average value of the six measurements to determine the correct cylinder liner grade.

Cylinder Liner Installation

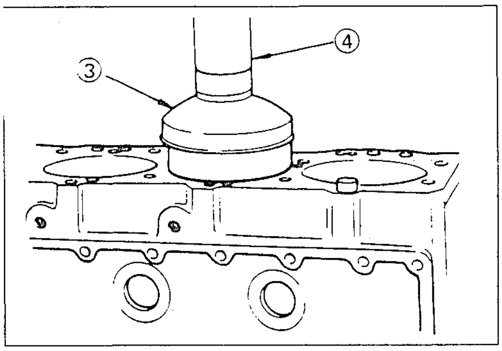
1. Cylinder Liner Installation Using The Special Tool.
    1) Use new kerosene or diesel oil to thoroughly clean the cylinder liners and bores.
    2) Use compressed air to blow-dry the cylinder liner and bore surfaces.

Note:

All foreign material must be carefully removed from the cylinder liner and the cylinder bore before installation.



3) Insert the cylinder liner ① into the cylinder body ② from the top of the cylinder body.



4) Set the cylinder liner installer ③ to the top of the cylinder liner.

    Cylinder Liner Installer: 5-8840-2040-0
    (4JA1, 4JB1)
    5-8840-9022-0
    (4JC1)

5) Position the cylinder body so that the installer center ③ is directly beneath the bench press shaft center ④.

Note:

Check that the cylinder liner is set perpendicular to the bench press and that there is no wobble.

6) Use the bench press to apply a seating force of 500 kg (1,102.5 lb/4,900 N) to the cylinder liner.
7) Apply a force of 2,500 kg (5,512.5 lb/24,500 N) to fully seat the cylinder liner.
8) After installing the cylinder liner, measure the cylinder liner projection.

    Refer to "Cylinder Liner Projection Inspection".

2. Cylinder Liner Installation Using Dry Ice

    If the cylinder liner is a chrome plated dry type, it is advisable to use dry ice during the installation procedure.
    Cooling the cylinder liner with dry ice will cause the cylinder liner to contact, thus making installation easier.

Note:

It is important that the cylinder liner be inserted to the cylinder body immediately after it has been cooled.

WARNING:
DRY ICE MUST BE USED WITH GREAT CARE. CARELESS HANDLING OF DRY ICE CAN RESULT IN SEVERE FROSTBITE.

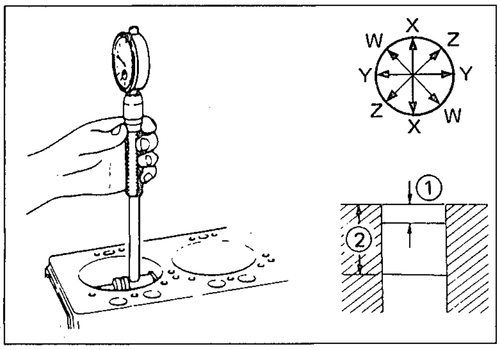
Cylinder Bore and Cylinder Liner Outside Diameter Combination (Reference)

For 4JA1 · 4JB1 mm(in)

	Cylinder Bore	Cylinder Liner Outside Diameter
1	95.001 — 95 010 (3.74019 — 3.74055)	95.011 — 95.020 (3.74059 — 3.74094)
2	95.011 — 95.020 (3.74059 — 3.74094)	95.021 — 95.030 (3.74098 — 3.74133)
3	95.021 — 95.030 (3.74098 — 3.74133)	95.031 — 95.040 (3.74137 — 3.74173)

For 4JC1 mm(in)

	Cylinder Bore	Cylinder Liner Outside Diameter
1	90.001 — 90 010 (3.54334 — 3.54724)	90.011 — 90.020 (3.54374 — 3.54409)
2	90.011 — 90.020 (3.54374 — 3.54409)	90.021 — 90.030 (3.54413 — 3.54448)
3	90.021 — 90.030 (3.54413 — 3.54448)	90.031 — 90.040 (3.54452 — 3.54488)



Piston Grade Selection

Measure the cylinder liner bore after installing the cylinder liner. Then select the appropriate piston grade for the installed cylinder liner.

1. Measure the cylinder liner bore.

   There are two measuring points (① and ②).

   Measure the cylinder liner bore in four different direction (W — W, X — X, and Z — Z) at both measuring points.

   Calculate the average value of the eight measurements to determine the correct cylinder liner bore.

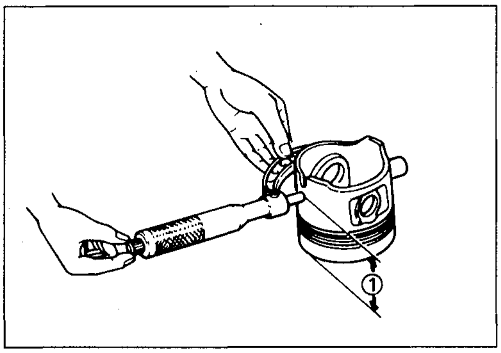
Measuring Points ①: 20 mm (0.79 in) for all 4J models
②: 140 mm (5.51 in) for 4JA1, 4JC1
160 mm (6.30 in) for 4JB1

Cylinder Liner Bore mm(in)

	Standard	Limit
4JA1 4JB1	93.021 — 93.060 (3.662 — 3.663)	93.10 (3.665)
4JC1	87.991 — 88.030 (3.464 — 3.466)	88.10 (3.468)

Note:

It is most important that the correct piston grade be used. Failure to select the correct piston grade will result in engine failure. Always measure the cylinder bore and select the correct piston grade.



2. Measure the piston outside diameter.

Piston Measuring Point ①: 70 mm (2.76 in)

Piston Grade mm(in)

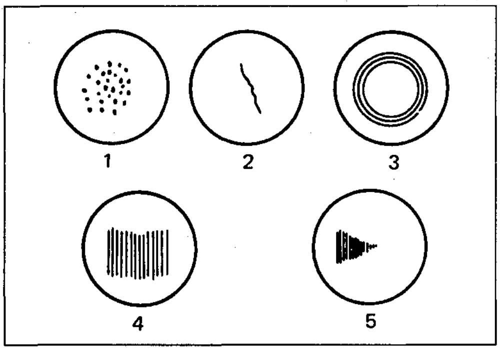
Grade	4JA1 · 4JB1	4JC1
Ⓐ	92.985 — 93.004 (3.660 — 3.662)	87.955 — 87.974 (3.462 — 3.464)
Ⓒ	93.005 — 93.024 (3.6616 — 3.6623)	87.975 — 87.994 (3.4635 — 3.4643)

Cylinder Liner and Piston Clearance mm(in)

0.025 — 0.045 (0.0010 — 0.0018)

Note:

:Cylinder liner kit clearances are preset. However, the cylinder liner installation procedure may result in slight decreases in cylinder liner clearances. Always measure the cylinder liner clearance after installation to be sure that it is correct.



TAPPET AND PUSH ROD

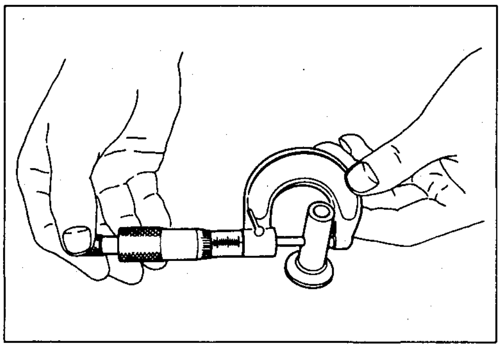
Visually inspect the tappet camshaft contact surfaces for pitting, cracking, and other abnormal conditions. The tappet must be replaced if any of these conditions are present.

Refer to the illustration at the left.

1 Normal contact
2 Cracking
3 Pitting
4 Irregular contact
5 Irregular contact

Note:

The tappet surfaces are spherical. Do not attempt to grind them with an oil stone or similar tool in an effort to repair the tappet. If the tappet is damaged, it must be replaced.

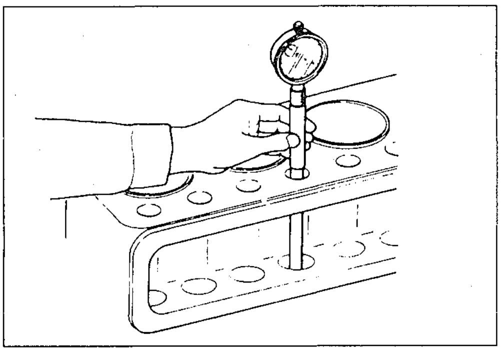


Tappet Outside Diameter

Measure the tappet outside diameter with a micrometer. If the measured value is less than the specified limit, the tappet must be replaced.

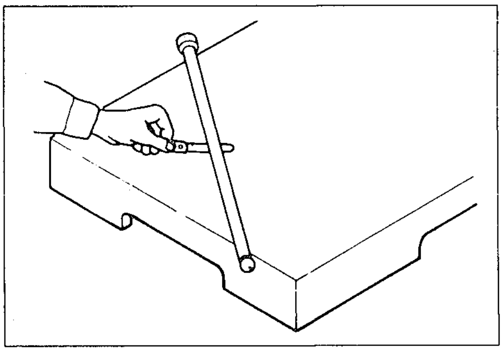
Tappet Outside Diameter mm(in)

Standard	Limit
12.97—12.99 (0.510—0.511)	12.95 (0.509)



Tappet and Cylinder Body Clearance mm(in)

Standard	Limit
0.03 (0.001)	0.1 (0.004)



Push Rod Curvature

1. Lay the push rod on a surface plate.
2. Roll the push rod along the surface plate and measure the push rod curvature with a thickness gauge.

   If the measured value exceeds the specified limit, the push rod must be replaced.

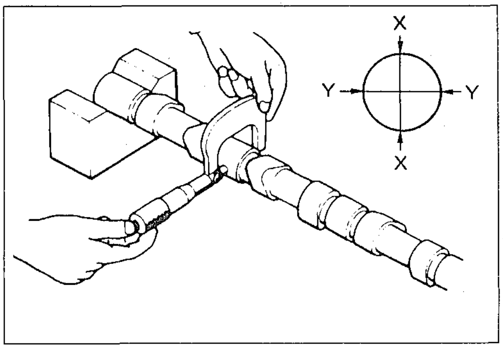
Push Rod Curvature mm(in)

Limit
0.3 (0.012)

3. Visually inspect both ends of the push rod for excessive wear and damage. The push rod must be replaced if these conditions are discovered during inspection.

CAMSHAFT

Visually inspect the journals, the cams, the oil pump drive gear, and the camshaft bearings for excessive wear and damage. The camshaft and the camshaft bearings must be replaced if these conditions are discovered during inspection.

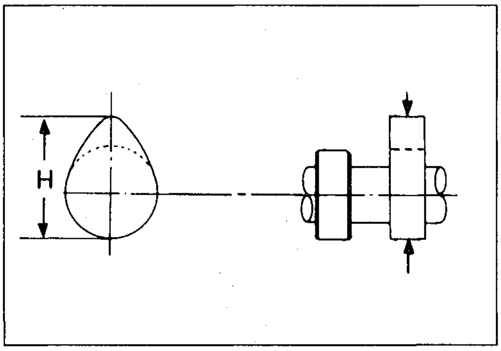


Camshaft Journal Diameter

Use a micrometer to measure each camshaft journal diameter in two directions ((X–X) and (Y–Y)). If the measured value is less than the specified limit, the camshaft must be replaced.

Camshaft Journal Diameter mm(in)

Standard	Limit
49.945 – 49.975 (1.966 – 1.965)	49.60 (1.953)

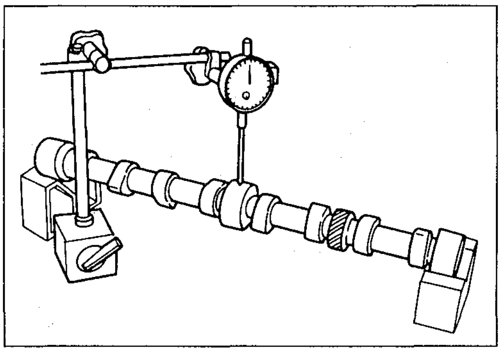


Cam Height

Measure the cam height (H) with a micrometer. If the measured value is less than the specified limit, the camshaft must be replaced.

Cam Height Ⓗ mm(in)

Standard	Limit
42.08 (1.65)	41.65 (1.64)



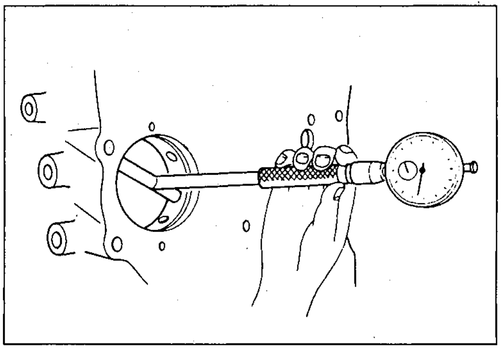
Camshaft Run-Out

1. Mount the camshaft on V-blocks.
2. Measure the run-out with a dial indicator.

   If the measured value exceeds the specified limit, the camshaft must be replaced.

Camshaft Run-Out mm(in)

Standard	Limit
0.02 (0.0008)	0.10 (0.004)



Camshaft and Camshaft Bearing Cleareance

Use an inside dial indicator to measure the camshaft bearing inside diameter.

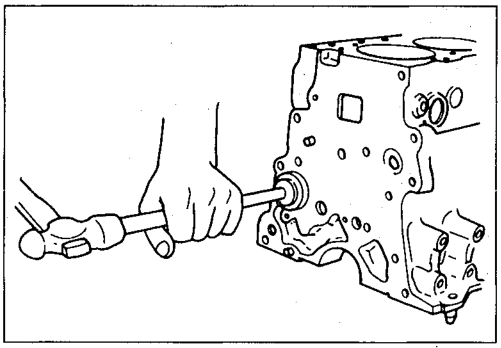
Camshaft Bearing Inside Diameter mm(in)

Standard	Limit
50.0 – 50.03 (1.9685 – 1.9696)	50.08 (1.9716)

If the clearance between the camshaft bearing inside diameter and the journal exceeds the specified limit, the camshaft bearing must be replaced.

Camshaft Bearing Clearance mm(in)

Standard	Limit
0.05 (0.002)	0.12 (0.005)

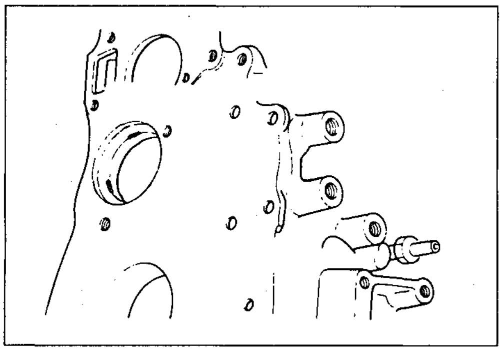


Camshaft Bearing Replacement

Camshaft Bearing Removal

1. Remove the cylinder body plug plate.
2. Use the camshaft bearing replacer to remove the camshaft bearing.

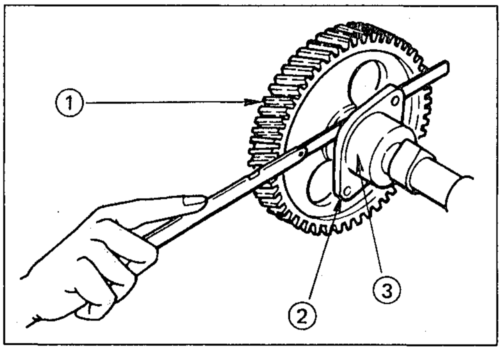
   Bearing Replacer: 5-8840-2038-0



Camshaft Bearing Installation

1. Align the bearing oil holes with the cylinder body oil holes.
2. Use the camshaft bearing replacer installer to install the camshaft bearing.

   Bearing Replacer: 5-8840-2038-0

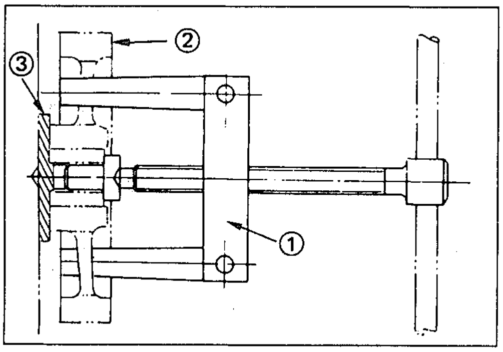


Camshaft End Play

1. Before removing the camshaft gear ①, push the thrust plate ② as far as it will go toward the camshaft gear ③.
2. Use a feeler gauge to measure the clearance between the thrust plate and the camshaft journal.
   If the measured value exceeds the specified limit, the thrust plate must be replaced.

Camshaft End Play mm(in)

Standard	Limit
0.050 – 0.114 (0.002 – 0.0044)	0.2 (0.008)

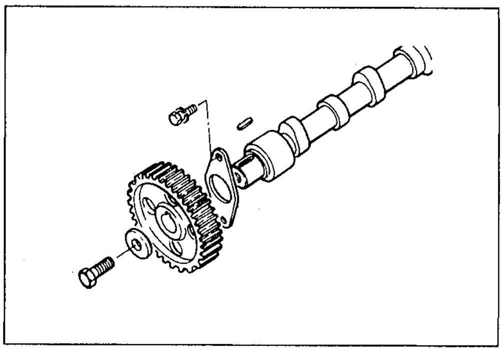


Thrust Plate Replacement

Thrust Plate Removal

1. Use the universal puller ① to remove the camshaft timing gear ②.

   Universal Puller: 5-8840-0086-0
2. Remove the thrust plate ③.



Thrust Plate Installation

1. Install the thrust plate.
2. Apply engine oil to the bolt setting face and the bolt threads.
3. Install the camshaft gear.

Camshaft Gear Torque kg·m(lb.ft/N·m)

11.0 ± 1.0 (79.5 ± 7.2/107.8 ± 9.8)

CRANKSHAFT AND BEARING

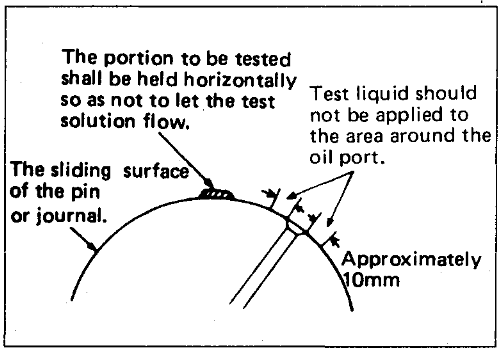
Inspect the surface of the crankshaft journals and crankpins for excessive wear and damage.

Inspect the oil seal fitting surfaces for excessive wear and damege.

Inspect the oil ports for obstructions.

Note:

To increase crankshaft strength, tufftriding (Nitrizing Treatment) has been applied. Because of this, it is not possible to regrind the crankshaft surfaces.


The portion to be tested shall be held horizontally so as not to let the test solution flow.
Test liquid should not be applied to the area around the oil port.
The sliding surface of the pin or journal.
Approximately 10mm

Crankshaft Tufftriding Inspection

1. Use an organic cleaner to thoroughly clean the crankshaft. There must be no traces of oil on the surfaces to be inspected.
2. Prepare a 5 — 10% solution of ammonium cuprous chloride (dissolved in distilled water).
3. Use a syringe to apply the solution to the surface to be inspected.

   Hold the surface to be inspected perfectly horizontal to prevent the solution from running.

Note:

Do not allow the solution to come in contact with the oil ports and their surrounding area.

Judgment

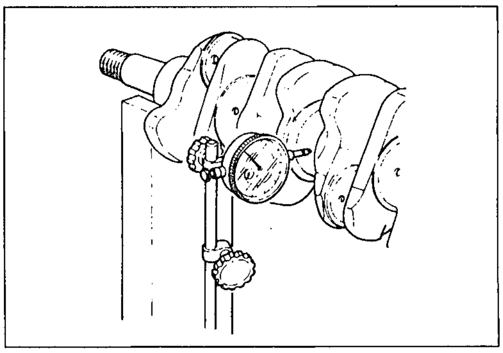
1. Wait for thirty to forty seconds.

   If there is no discoloration after thirty or forty seconds, the crankshaft is usable.

   If discoloration appears (the surface being tested will become the color of copper), the crankshaft must be replaced.
2. Steam clean the crankshaft surface immediately after completing the test.

Note:

The ammonium cuprous chloride solution is highly corrosive. Because of this, it is imperative that the surfaces being tested be cleaned immediately after completing the test.

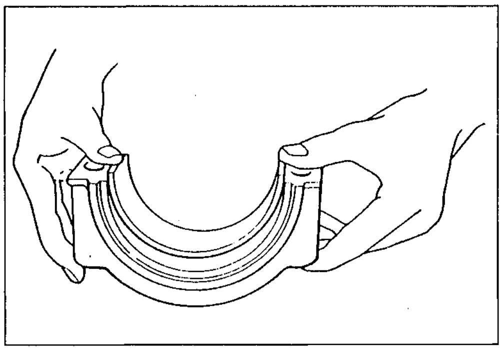


Crankshaft Run-Out

1. Set a dial indicator to the center of the crankshaft journal.
2. Gently turn the crankshaft in the normal direction of rotation.
   Read the dial indicator as you turn the crankshft.
   If the measured value exceeds the specified limit, the crankshaft must be replaced.

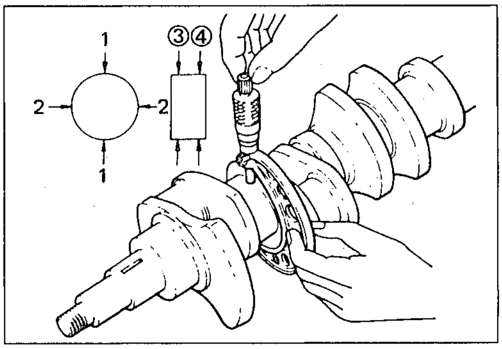
Crankshaft Run-Out mm(in)

Standard	Limit
0.05 (0.002) or less	0.08 (0.003)



Bearing Tension

Check to see if the bearing has enough tension, so that a good finger pressure is needed to fit the bearing into position.



Crankshaft Journal and Crankpin Diameter

1. Use a micrometer to measure the crankshaft journal diameter across points ("1 — 1") and ("2 — 2").
2. Use the micrometer to measure the crankshaft journal diameter at the two points (③ and ④).
3. Repeat Steps 1 and 2 to measure the crankpin diameter.

   If the measured values are less than the limit, the crankshaft must be replaced.

Crankshaft Journal Diameter mm(in)

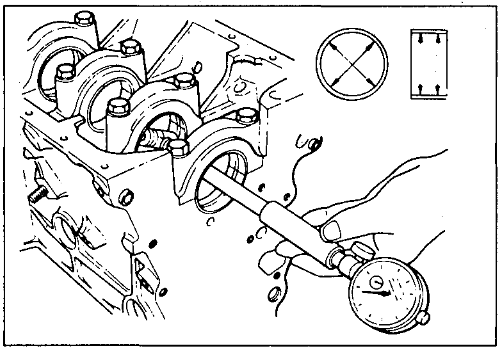
	Standard	Limit
4JA1 4JC1	59.917 — 59.932 (2.3589 — 2.3595)	59.910 (2.3587)
4JB1	69.917 — 69.932 (2.7526 — 2.7531)	69.910 (2.7524)

Crankpin Diameter mm(in)

	Standard	Limit
4JA1 4JB1 4JC1	52.915 — 52.930 (2.0833 — 2.0839)	52.906 (2.0829)

Crankshaft Journal and Crankpin Uneven Wear mm(in)

Standard	Limit
0.05 (0.002) or less	0.08 (0.003)



Crankshaft Journal and Bearing Clearance

If the clearance between the measured bearing inside diameter and the crankshaft journal diameter exceeds the specified limit, the bearing and/or the crankshaft must be replaced.

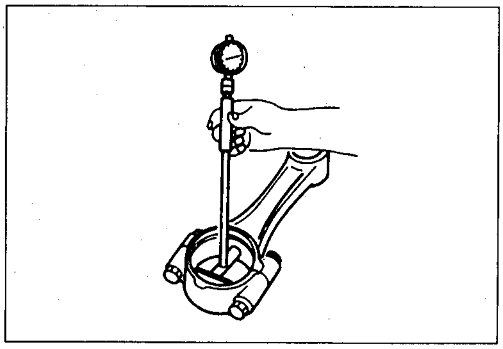
Crankshaft Bearing Cap Bolt Torque kg·m(lb.ft./N·m)

17.0±1.0 (122.9±7.2/166.6±9.8)

Crankshaft brg' cap Bolt Torque

Crankshaft Journal and Bearing Clearance mm(in)

Standard	Limit
0.035 — 0.080 (0.0014 — 0.0036)	0.11 (0.0043)



Connecting Rod Bearing Inside Diameter

1. Install the bearing to the connecting rod big end.
2. Tighten the bearing cap to the specified torque.

Connecting Rod Bearing Cap Bolt Torque kg·m(lb.ft/N·m)

8.5 ± 0.5 (61.5 ± 3.6/83.4 ± 4.9)

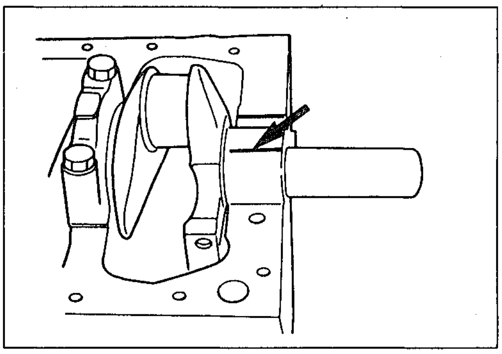
3. Use a inside dial indicator to measure the connecting rod bearing inside diameter.

Crankpin and Bearing Clearance

If the clearance between the measured bearing inside diameter and the crankpin exceeds the specified limit, the bearing and/or the crankshaft must be replaced.

Crankpin and Bearing Clearance mm(in)

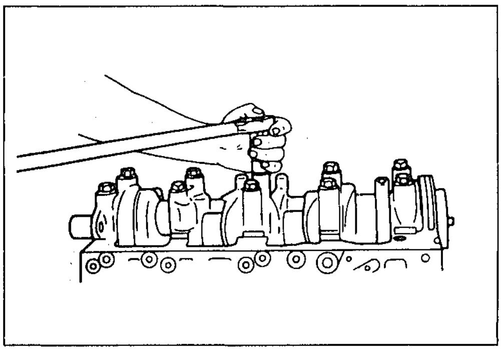
Standard	Limit
0.029 — 0.066 (0.0011 — 0.0026)	0.10 (0.0039)



Clearance Measurements (With Plastigage)

Crankshaft Journal and Bearing Clearance

1. Clean the cylinder body, the journal bearing fitting surface, the bearing caps, and the bearings.
2. Install the bearings to the cylinder body.
3. Carefully place the crankshaft on the bearings.
4. Rotate the crankshaft approximately 30° to seat the bearing.
5. Place the Plastigage (arrow) over the crankshaft journal across the full width of the bearing.
6. Install the bearing caps with the bearing.



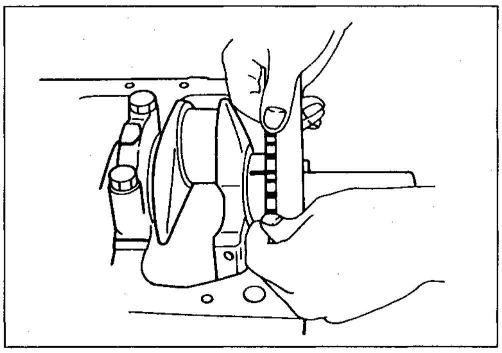
7. Tighten the bearing caps to the specified torque.

Crankshaft Bearing Cap Bolt
Torque kg·m(lb.ft/N·m)

17.0 ± 1.0 (122.9 ± 7.2/166.6 ± 9.8)

Do not allow the crankshaft to turn during bearing cap installation and tightening.

8. Remove the bearing cap.



9. Compare the width of the Plastigage attached to either the crankshaft or the bearing against the scale printed on the Plastigage container.

   If the measured value exceeds the limit, perform the following additionsl steps.

   1) Use a micrometer to measure the crankshaft outside diameter.
   2) Use an inside dial indicator to measure the bearing inside diameter.

      If the crankshaft journal and bearing clearance exceeds the limit, the crankshaft and/or the bearing must be replaced.

Crankshaft Journal and Bearing Clearance mm(in)

Standard	Limit
0.035 — 0.080 (0.0014 — 0.0036)	0.11 (0.0043)

Crankpin and Bearing Clearance

1. Clean the crankshaft, the connecting rod, the bearing cap, and the bearings.
2. Install the bearing to the connecting rod and the bearing cap.

   Do not allow the crankshaft to move when installing the bearing cap.
3. Prevent the connecting rod from moving.
4. Attach the Plastigage to the crankpin.

   Apply engine oil to the Plastigage to keep it from falling.

5. Install the bearing cap and tighten it to the specified torque.

   Do not allow the connecting rod to move when installing and tightening the bearing cap.

Connecting Rod Bearing Cap Bolt
Torque kg·m(lb.ft/N·m)

8.5 ± 0.5 (61.5 ± 3.6/83.3 ± 4.9)

6. Remove the bearing cap.
7. Compare the width of the Plastigage attached to either the crankshaft or the bearing against the scale printed on the Plastigage container.

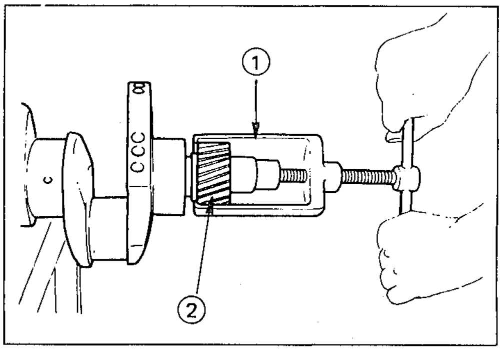
   If the measured value exceeds the specified limit, perform the following additional steps.

   1) Use a micrometer to measure the crankpin outside diameter.
   2) Use an inside dial indicator to measure the bearing inside diameter.

      If the crankpin and bearing clearance exceeds the specified limit, the crankshaft and/or the bearing must be replaced.

Crankpin and Bearing Clearance mm(in)

Standard	Limit
0.029 — 0.066 (0.0011 — 0.0026)	0.10 (0.0039)

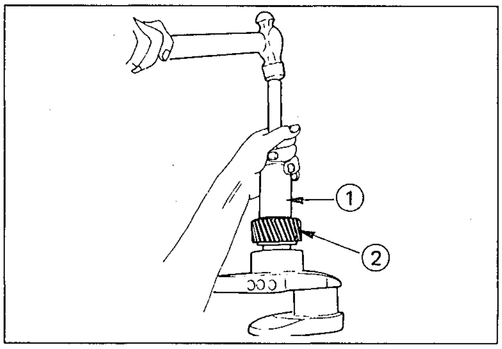


Crankshaft Timing Gear Replacement

Crankshaft Timing Gear Removal

1. Use the crankshaft gear remover ① to remove the crankshaft gear ②.
2. Remove the crankshaft feather key.

   Crankshaft Timing Gear Remover: 9-8840-2057-0



Crankshaft Timing Gear Installation

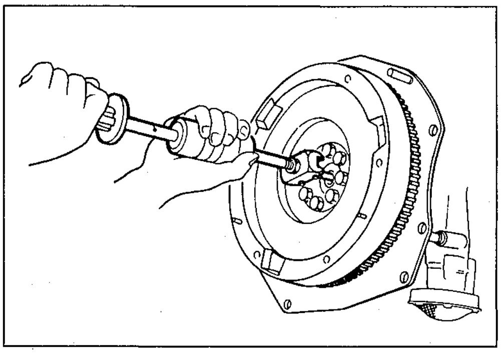
1. Install the crankshaft gear.
2. Use the crankshaft gear installer ① to install the crankshaft gear ②.

   The crankshaft gear timing mark ("X—X") must be facing outward.

   Crankshaft Gear Installer: 9-8522-0020-0

CRANKSHAFT PILOT BEARING

Check the crankshaft pilot bearing for excessive wear and damage and replace it if necessary.

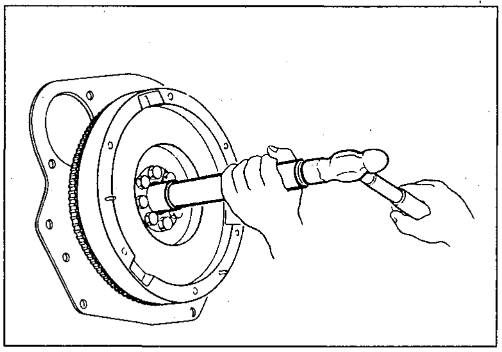


Crankshaft Pilot Bearing Replacement

Crankshaft Pilot Bearing Removal

Use the pilot bearing remover to remove the pilot bearing.

Pilot Bearing Remover: 5-8840-2000-0
Sliding Hammer: 5-8840-0019-0



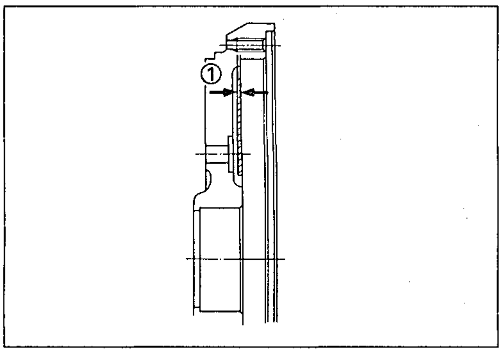
Crankshaft Pilot Bearing Installation

1. Place the crankshaft pilot bearing horizontally across the crankshaft bearing installation hole.
2. Tap around the edges of the crankshaft pilot bearing outer races with a brass hammer to drive the bearing into the crankshaft bearing installation hole.

   Pilot Bearing Installer: 5-8522-0024-0

Note:

Strike only the crankshaft pilot bearing outer races with the hammer. Do not strike the bearing inner races. Bearing damage and reduced bearing service life will result.



FLYWHEEL AND RING GEAR

Flywheel

1. Inspect the flywheel friction surface for excessive wear and heat cracks.
2. Measure the flywheel friction surface wear amount (depth)

   The flywheel friction surface area actually making contact with the clutch driven plate (the shaded area in the illustration) will be smaller than the original machined surface area.

   There will be a ridge on the flywheel surface area. Be sure to measure the surface wear in the area inside the ridge.

   If the measured value is between the standard and the specified limit, the flywheel may be reground.

   If the measured value exceeds the specified limit, the flywheel must be replaced.

Flywheel Friction Surface Depth ① mm(in)

Limit
1.0 (0.04) or more

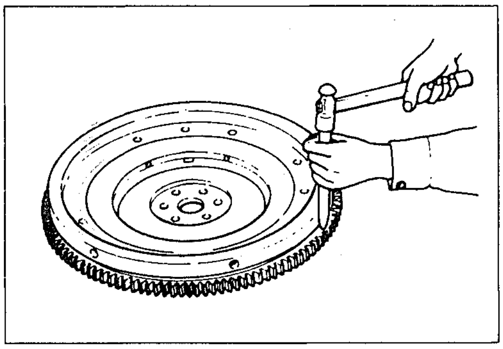
Note:

Because a ridge is produced at the flywheel friction surface as illustrated, do not measure the friction surface wear amount at the non-ridge area but be sure to measure it at the rear-friction surface which is shown in the illustration by shaded area.

Ring Gear

Inspect the ring gear.

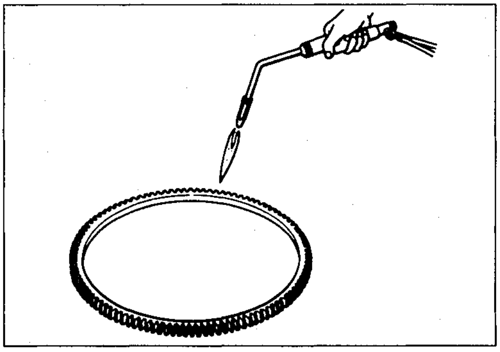
If the ring gear teeth are broken or excessively worn, the ring gear must be replaced.



Ring Gear Replacement

Ring Gear Removal

Strike around the edges of the ring gear with a hammer and diesel to remove it.



Ring Gear Installation

1. Heat the ring gear evenly with a gas burner to invite thermal expansion.

   Do not allow the temperature of the gas burner to exceed 200°C (390°F).
2. Install the ring gear when it is sufficiently heated.

   The ring gear must be installed with the chamfer facing the clutch.

Note:

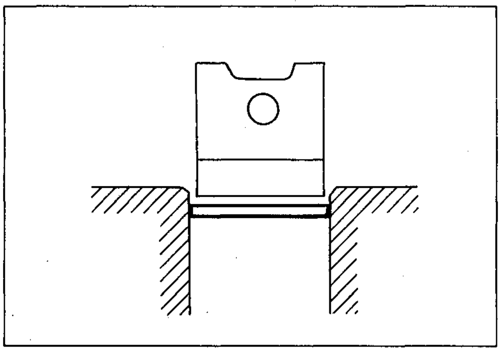
Another method of heating the ring gear to invite thermal expansion is to soak a rag in diesel fuel, wrap the diesel fuel soaked rag around the rim of the ring gear, and then light the rag.

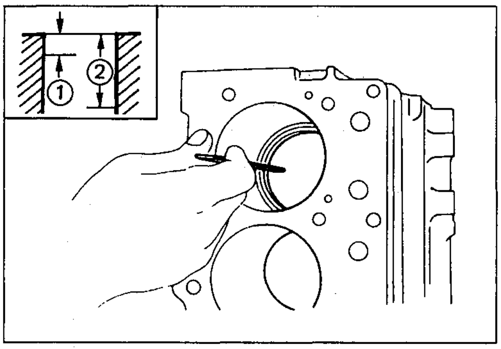
PISTON

Piston Grade Selection and Cylinder Liner Bore Measurement

Refer to the Section "CYLINDER BODY", Item "Cylinder Liner Bore Measurement" for details on piston grade selection and cylinder or liner bore measurement.

PISTON RING





Piston Ring Gap

1. Insert the piston ring horizontally into the cylinder liner.
2. Use a piston inserted upside down to push the piston ring into the cylinder liner until it reaches either measuring point ① or measuring point ②. Cylinder liner diameter is the smallest at these two points.

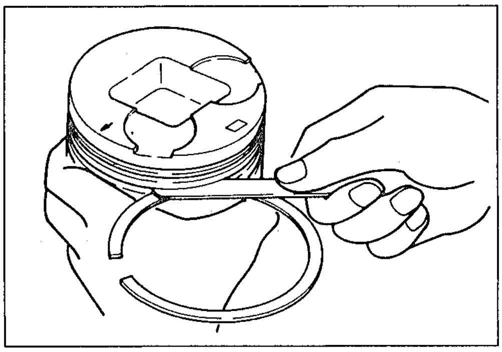
   Do not allow the piston ring to slant to one side or the other. It must be perfectly horizontal.
3. Use a feeler gauge to measure the piston ring gap.

   Measuring Point ①: 10 mm (0.39 in) or
   Measuring Point ②: 120 mm (4.72 in)

   If the piston ring gap exceeds the specified limit, the piston ring must be replaced.

Piston Ring Gap mm(in)

	Standard	Limit
1st Compression Ring	0.2 – 0.4 (0.008 – 0.016)	1.5 (0.059)
2nd Compression Ring		
Oil Ring	0.1 – 0.3 (0.004 – 0.012)	



Piston Ring and Piston Ring Groove Clearance

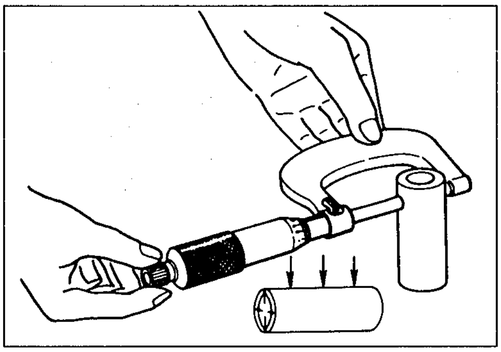
Use a feeler gauge to measure the clearance between the piston ring and the piston ring groove at several points around the piston.

If the clearance between the piston ring and the piston ring groove exceeds the specified limit, the piston ring must be replaced.

Piston Ring and Piston Ring Groove Clearance mm(in)

	Standard	Limit
1st Compression Ring	0.09 – 0.125 (0.0035 – 0.0049)	0.15 (0.006)
2st Compression Ring	0.05 – 0.075 (0.002 – 0.003)	
Oil Ring	0.03 – 0.07 (0.0012 – 0.0028)	

Visually inspect the piston. If a piston ring groove is damaged or distorted, the piston must be replaced.



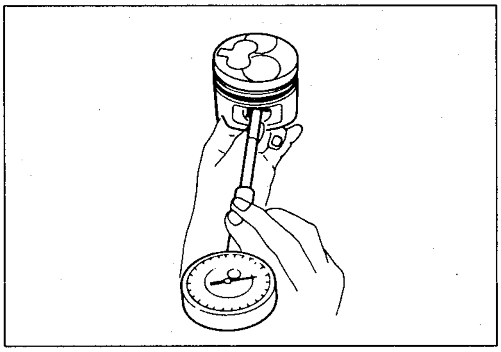
PISTON PIN

Piston Pin Diameter

Use a micrometer to measure the piston pin outside diameter at several points.
If the measured value is less than the specified limit, the piston pin must be replaced.

Piston Pin Diameter mm(in)

Standard	Limit
31.0 (1.220)	30.97 (1.219)



Piston Pin and Piston Clearance

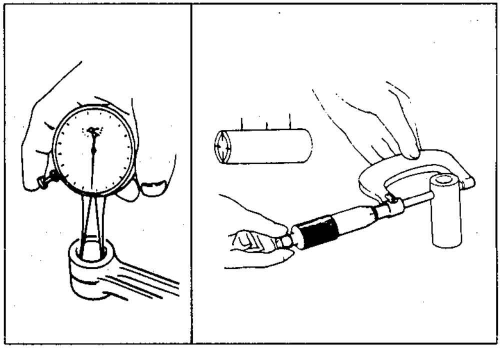
Use an inside dial indicator to measure the piston pin hole (in the piston).

Piston Pin Hole mm(in)

Standard
29.002 — 29.007

Piston Pin and Piston Pin Hole Clearance mm(in)

0.002 — 0.015 (0.00008 — 0.0006)



Piston Pin and Connecting Rod Small End Bushing Clearance

Use a caliper calibrator and a dial indicator to measure the piston pin and connecting rod small end bushing clearance.

If the clearance between the piston pin and the connecting rod small end bushing exceeds the specified limit, replace the piston pin and/or the connecting rod bushing.

Piston Pin and Connecting Rod Small End Bushing Clearance mm(in)

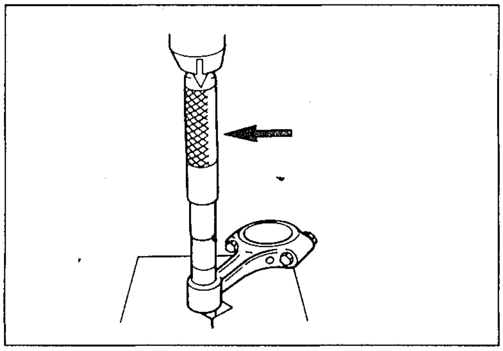
Standard	Limit
0.008 — 0.020 (0.0003 — 0.0008)	0.05 (0.002)

Connecting Rod Bushing Replacement

Connecting Rod Bushing Removal

1. Clamp the connecting rod ina vise.
2. Use the connecting rod bushing remover to remove the connecting rod bushing.

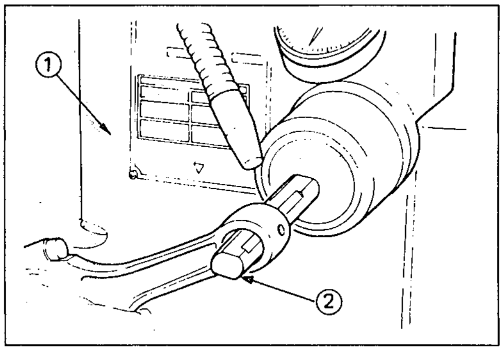
Connecting Rod Bushing Replacer



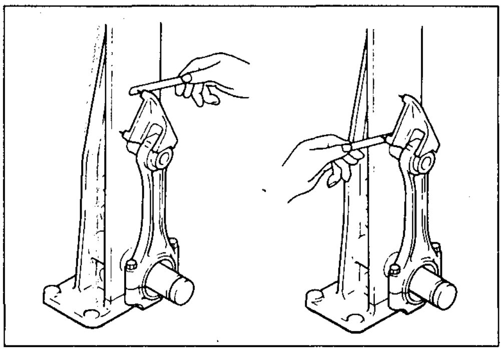
Connecting Rod Bushing Installation

1. Clamp the connecting rod in a vice.
2. Use the connecting rod bushing installer to install the connecting rod bushing.

Connecting Rod Bushing Replacer:



3. Use a piston pin hole grinder ① fitted with a reamer ② to ream the piston pin hole.



CONNECTING ROD

Connecting Rod Alignment

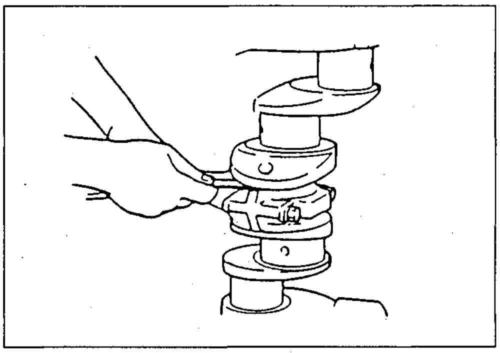
Use a connecting rod aligner to measure the distortion and the parallelism between the connecting rod big end hole and the connecting rod small end hole.

If either the measured distortion or parallelism exceed the specified limit, the connecting rod must be replaced.

Connecting Rod Alignment

Per Length of 100 mm (3.94 in) mm(in)

	Standard	Limit
Distortion	0.05 or Less (0.0020)	0.20 (0.008)
Parallelism		0.15 (0.006)



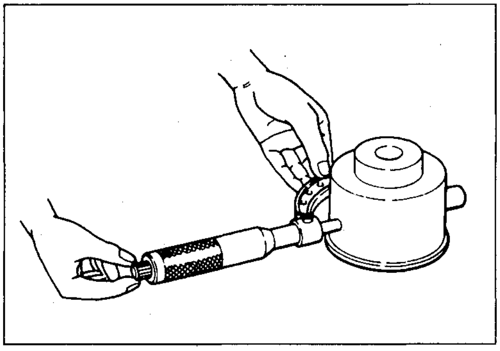
Connecting Rod Side Face Clearance

1. Install the connecting rod to the crankpin.
2. Use a feeler gauge to measure the clearance between the connecting rod big end side face and the crankpin side face.

   If the measured value exceeds the specified limit, the connecting rod must be replaced.

Connecting Rod and Crankpin Side Face Clearance mm(in)

Standard	Limit
0.23 (0.009)	0.35 (0.014)



IDLER GEAR SHAFT AND IDLER GEAR

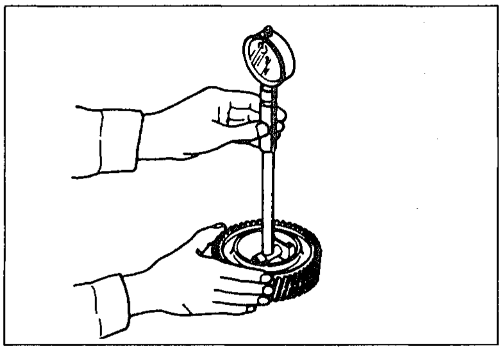
Idler Gear Shaft Outside Diameter

Use a micrometer to measure the idler gear shaft outside diameter.

If the measured value is less than the specified limit, the idler gear must be replaced.

Idler Gear Shaft Outside Diameter mm(in)

Standard	Limit
44.95 — 44.98 (1.769 — 1.770)	44.90 (1.767)



Idler Gear "A" Inside Diameter

1. Use an inside dial indic ator to measure the idler gear

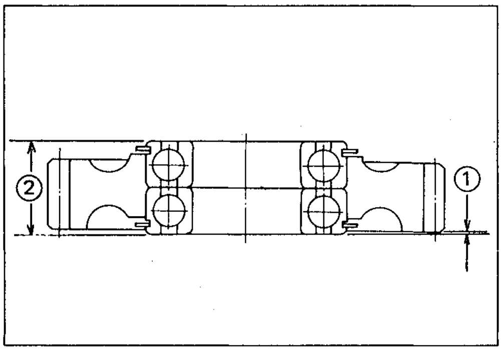
Idler Gear Inside Diameter mm(in)

Standard	Limit
45.0 — 45.03 (1.7717 — 1.7718)	45.10 (1.7756)

If the clearance between the idler gear shaft outside diamerer and the idler gear inside diameter exceeds the limit, the idler gear must be replaced.

Idler Gear Shaft and Idler Gear Clearance mm(in)

Standard	Limit
0.025 — 0.085 (0.0010 — 0.0033)	0.2 (0.008)



Idler Gear "B"

Bearing replacement

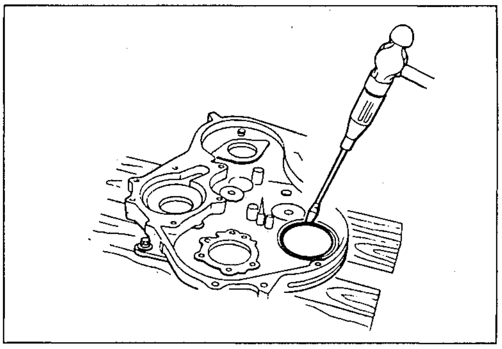
Use a suitable bar and a bench press or hammer.
Bearing projection amount should be within the specified height.

mm(in)

Projection	①	0.4 — 0.6 (0.016 — 0.024)
Height	②	23.7 — 24.0 (0.933 — 0.945)

TIMING GEAR CASE COVER

Replace the crankshaft front oil seal if it is excessively worn or damaged.

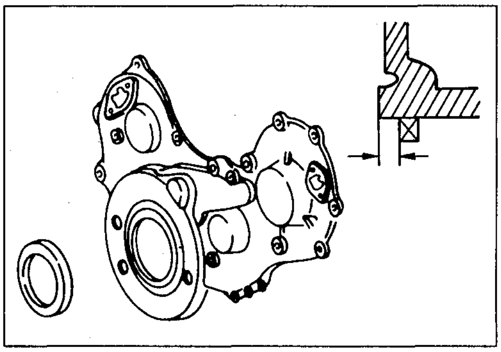


Crankshaft Front Oil Seal Replacement

Oil Seal Removal

Use a plastic hammer and a screwdriver to tap around the oil seal to free it from the gear case.

Take care not to damage the oil seal fitting surfaces.

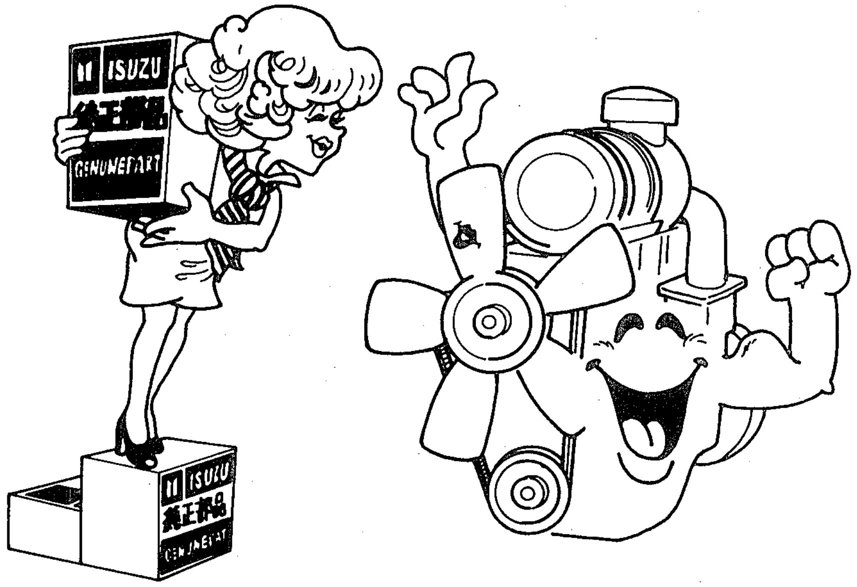


Oil Seal Installation

1. Apply a coat of engine oil to the oil seal lip circumference.
2. Use the oil seal installer and the installer grip to insert the oil seal 1 mm (0.039 in) into the front portion of the timing gear case.

   Oil Seal Installer : 5-8840-2061-0

MEMO


ISUZU
純正部品
GENUINE PART
ISUZU
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GENUINE PART

"QUALITY PARTS YOU CAN TRUST"

SECTION 5

ENGINE ASSEMBLY — III

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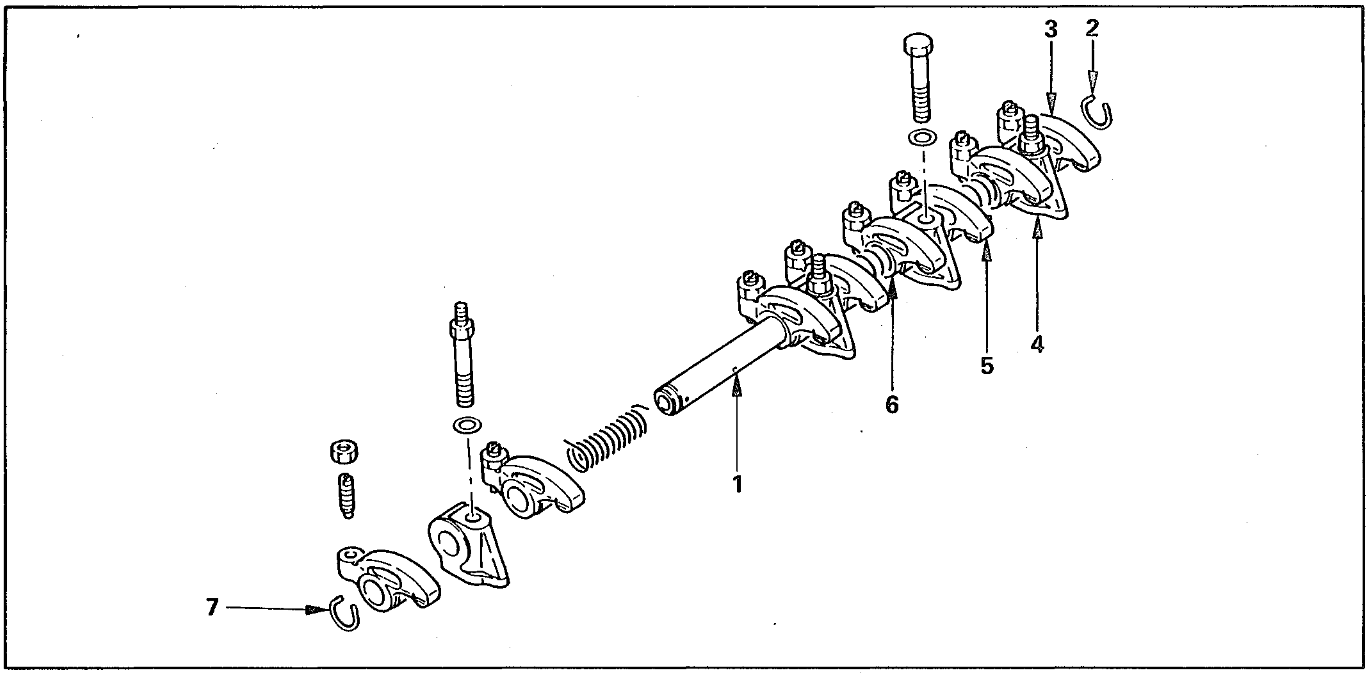
Reassembly .... 5— 1

REASSEMBLY

SINGLE UNIT

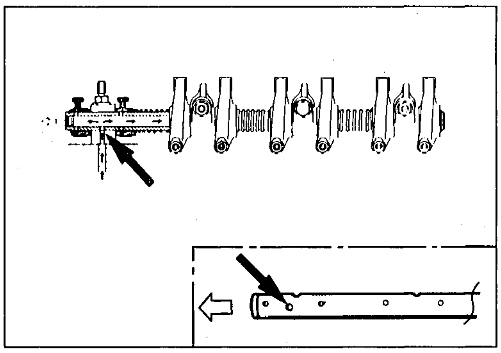
ROCKER ARM SHAFT AND ROCKER ARM



Reassembly Steps

▲ 1. Rocker arm shaft
2. Rocker arm shaft snap ring
3. Rocker arm
4. Rocker arm shaft bracket
5. Rocker arm
6. Rocker arm shaft spring
7. Rocker arm shaft snap ring

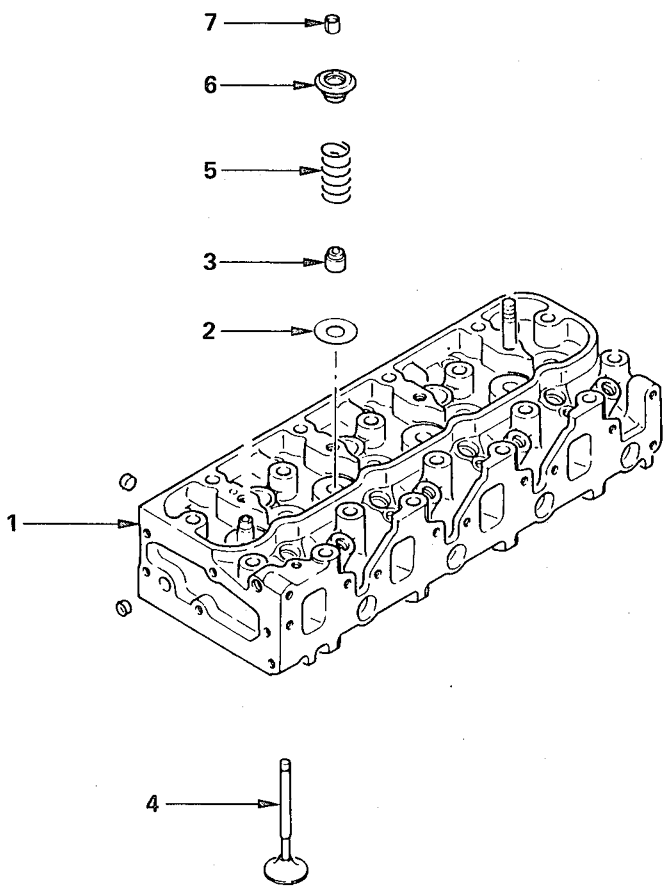
Important Operations



1. Rocker Arm Shaft

1) Position the rocker arm shaft with the large oil hole (4ϕ) facing the front of the engine.
2) Install the rocker arm shaft together with the rocker arm, the rocker arm shaft bracket, and the spring.

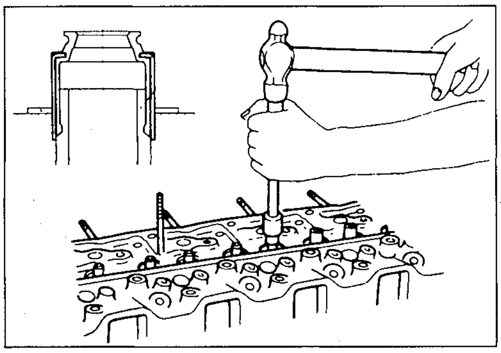
CYLINDER HEAD



Reassembly Steps

1. Cylinder head
2. Valve spring lower washer
3. ▲ Valve stem oil seal
4. ▲ Intake and exhaust valve
5. ▲ Valve spring
6. Valve spring upper seat
7. ▲ Split collar

Important Operations



3. Valve Stem Oil Seal

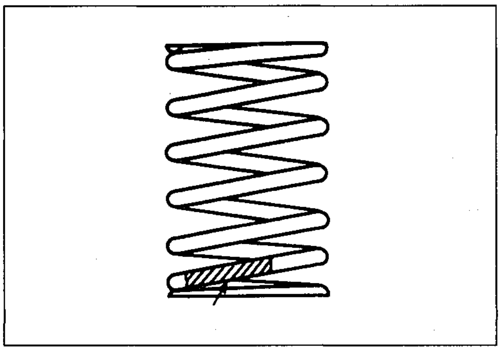
1) Apply a coat engine oil to the oil seal inner face.
2) Use an oil seal installer to install the oil seal to the valve guide.

   Oil Seal Installer: 5-8840-2033-0

4. Intake and Exhaust Valve

1) Apply a coat of engine oil to valve stem.
2) Install the intake and exhaust valves.
3) Turn the cylinder head up to install the valve springs.

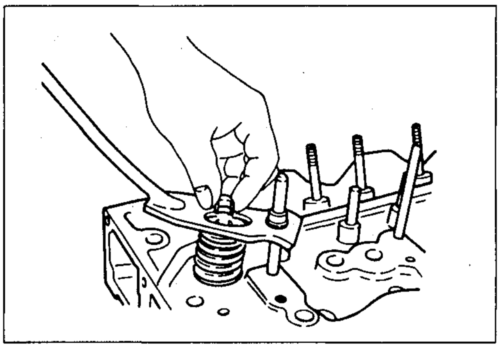
   Take care not to allow the installed valves to fall free.



5. Valve Spring

1) Turn the cylinder head up to install the valve springs.
2) Install the valve springs with the fine pitched end (painted pink) facing down.

   Take care not to allow the installed valves to fall free.

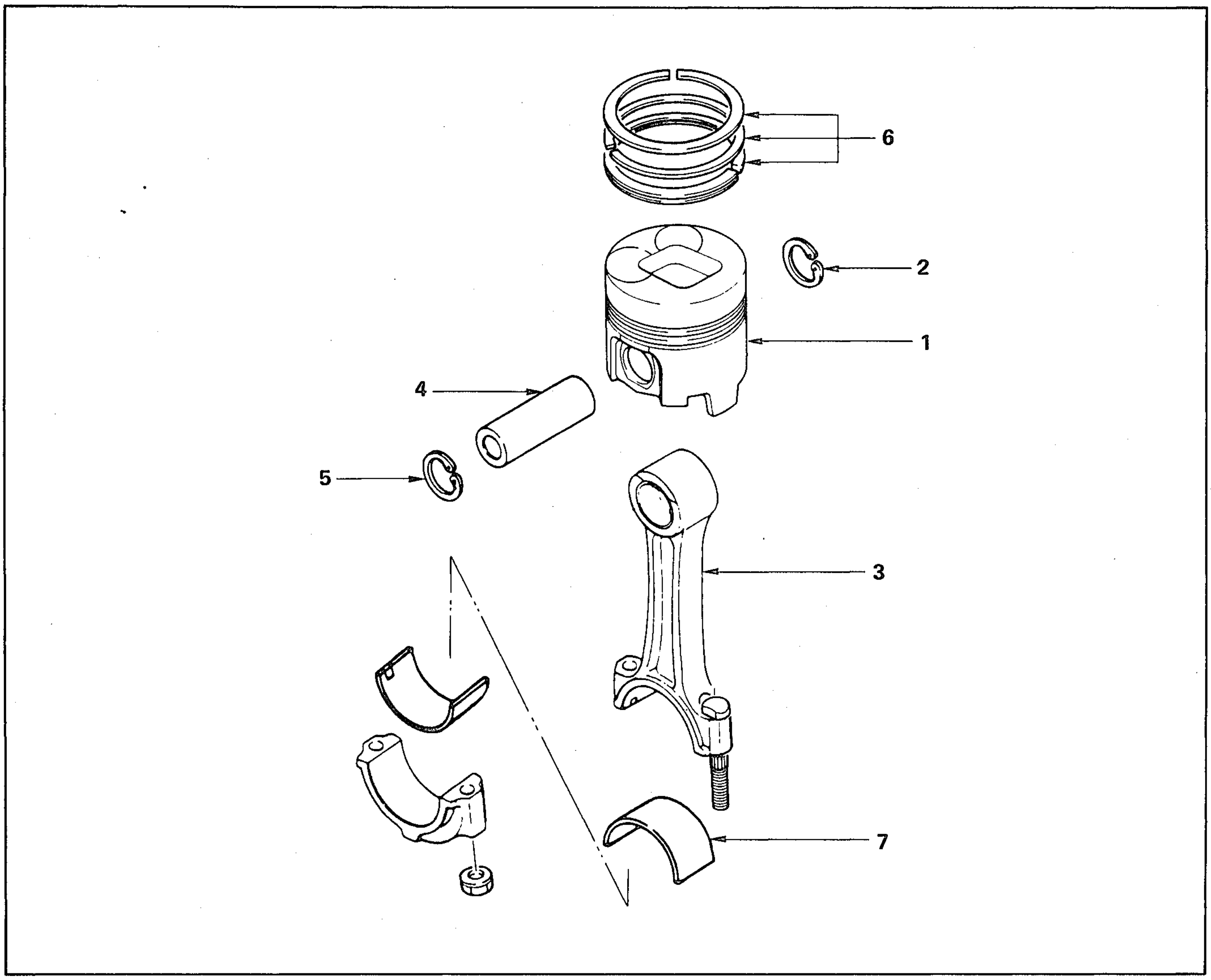


7. Split Collar

1) Use the spring compressor to push the valve spring into position.

   Spring Compressor: 9-8523-1423-0
2) Install the split collar to the valve stem.
3) Set the split collar by tapping around the bead of the collar with a rubber hammer.

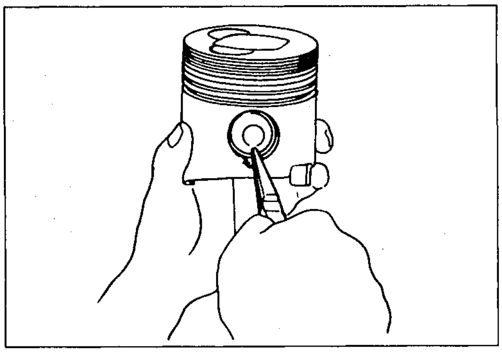
PISTON AND CONNECTING ROD



Reassembly Steps

- ▲ 1. Piston
- ▲ 2. Piston pin snap ring
- ▲ 3. Connecting rod
- ▲ 4. Piston pin
- 5. Piston pin snap ring
- ▲ 6. Piston ring
- ▲ 7. Connecting rod bearing

Important Operations



1. Piston

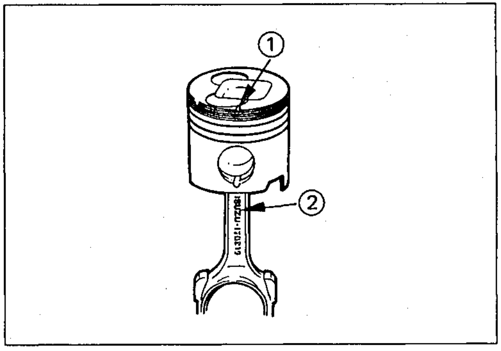
2. Piston pin snap ring

3. Connecting rod

1) Clamp the connecting rod in a vise.

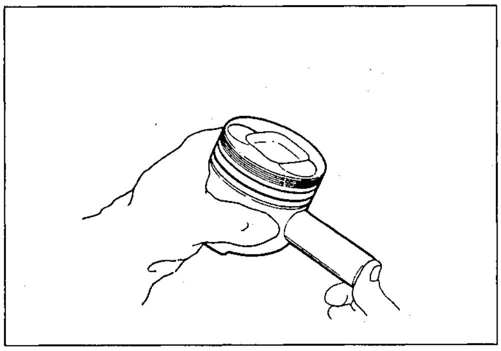
   Take care not to damage the connecting rod.

2) Use a pair of snap ring pliers to install the piston pin snap ring to the piston.



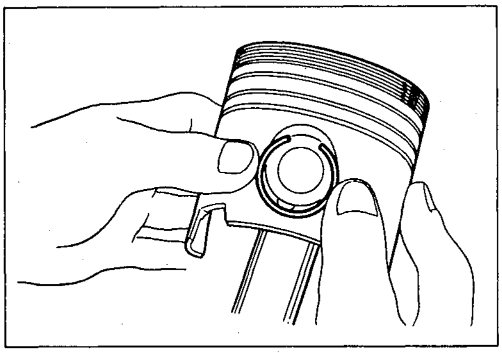
3) Install the piston to the connecting rod.

   The piston head front mark ① and the connecting rod "ISUZU" casting mark ② must be facing the same direction.

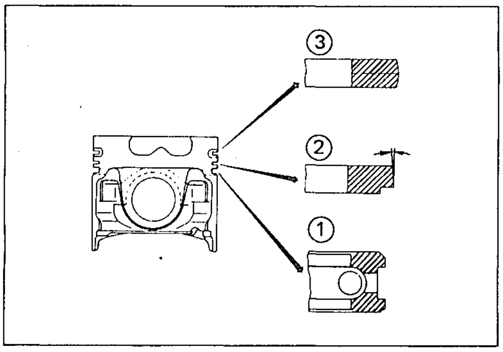


4. Piston pin

1) Apply a coat of engine oil to the piston pin and the piston pin hole.
2) Use your fingers to force the piston pin into the piston until it makes contact with the snap ring.



3) Use your fingeas to force the piston pin snap ring into the piston snap ring groove.
4) Check that the connecting rod moves smoothly on the piston pin.



6. Piston Ring

1) Use a piston ring replacer to install the three piston rings.

Piston Ring Replacer:

Install the piston rings in the order shown in the illustration.

① Oil ring (Coil expander type)
② 2nd compression ring (Taper undercut type)
③ 1st compression ring (Barrel face type)

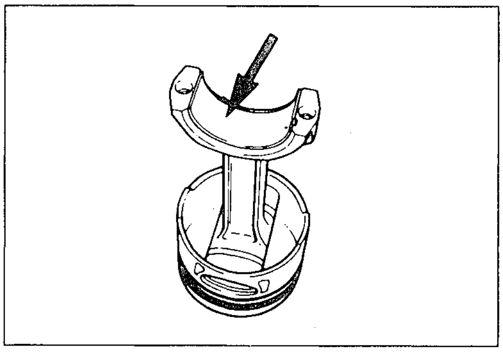
Note:

Install the compression rings with the stamped side facing up.

Insert the expander coil into the oil ring groove so that there is no gap on either side of the expander coil before installing the oil ring.

2) Apply engine oil to the piston ring surfaces.

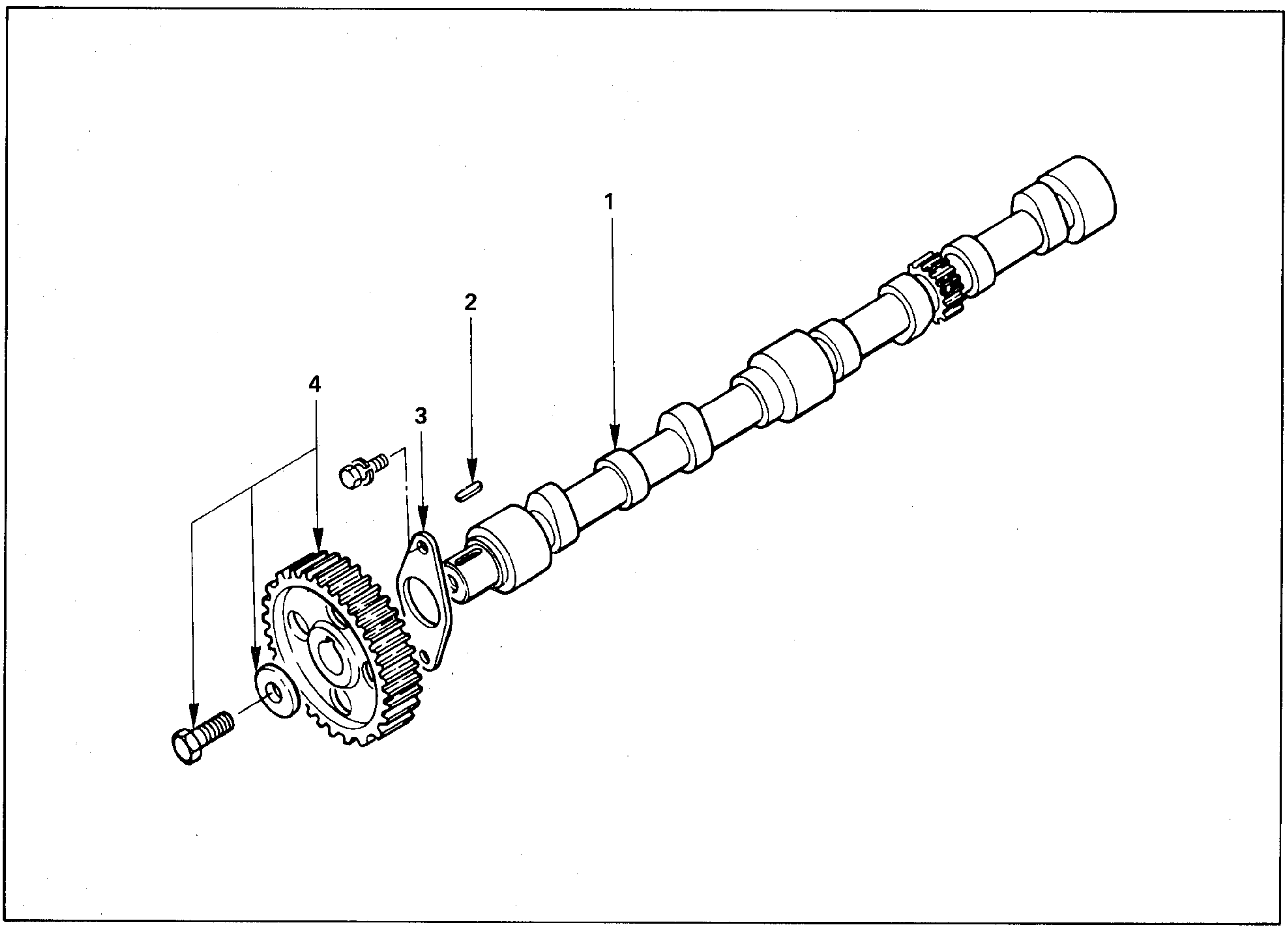
3) Check that the piston rings rotate smoothly in the piston ring grooves.



7. Connecting Rod Bearing

Carefully wipe any oil or other foreign material from the connecting red bearing back face and the connecting rod bearing fitting surface.

CAMSHAFT, CAMSHAFT TIMING GEAR, AND THRUST PLATE

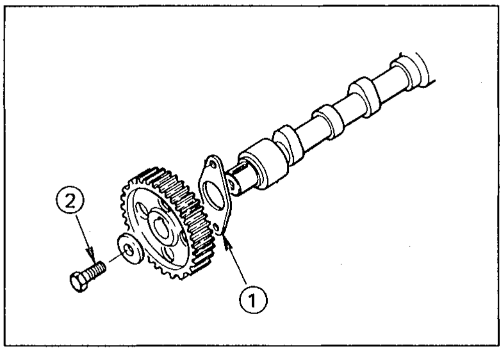


Reassembly Steps

1. Camshaft
2. Feather key
3. Thrust plate

▲ 4. Camshaft timing gear

Important Operations



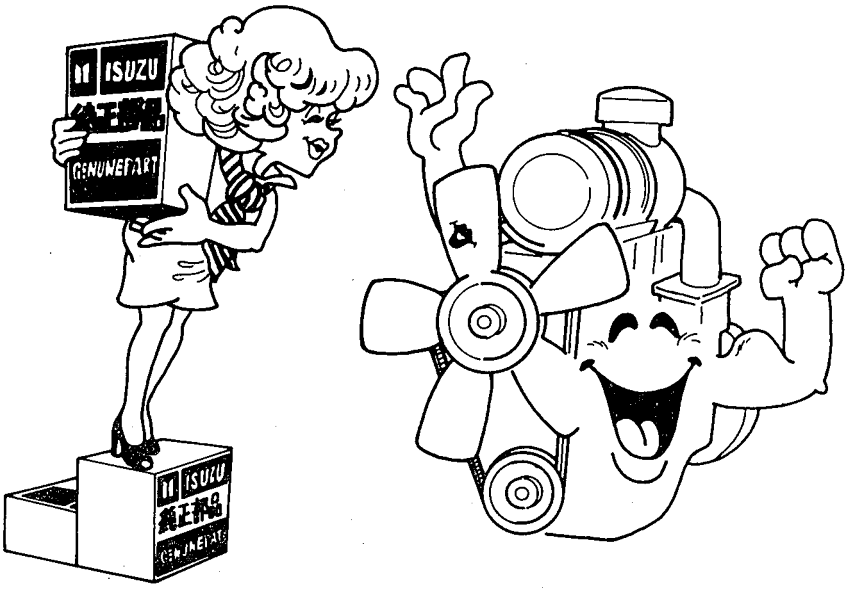
4. Camshaft Timing Gear

1) Install the thrust plate ①.
2) Apply engine oil to the bolt threads ②.
3) Install the camshaft timing gear with the timing mark stamped side facing out.

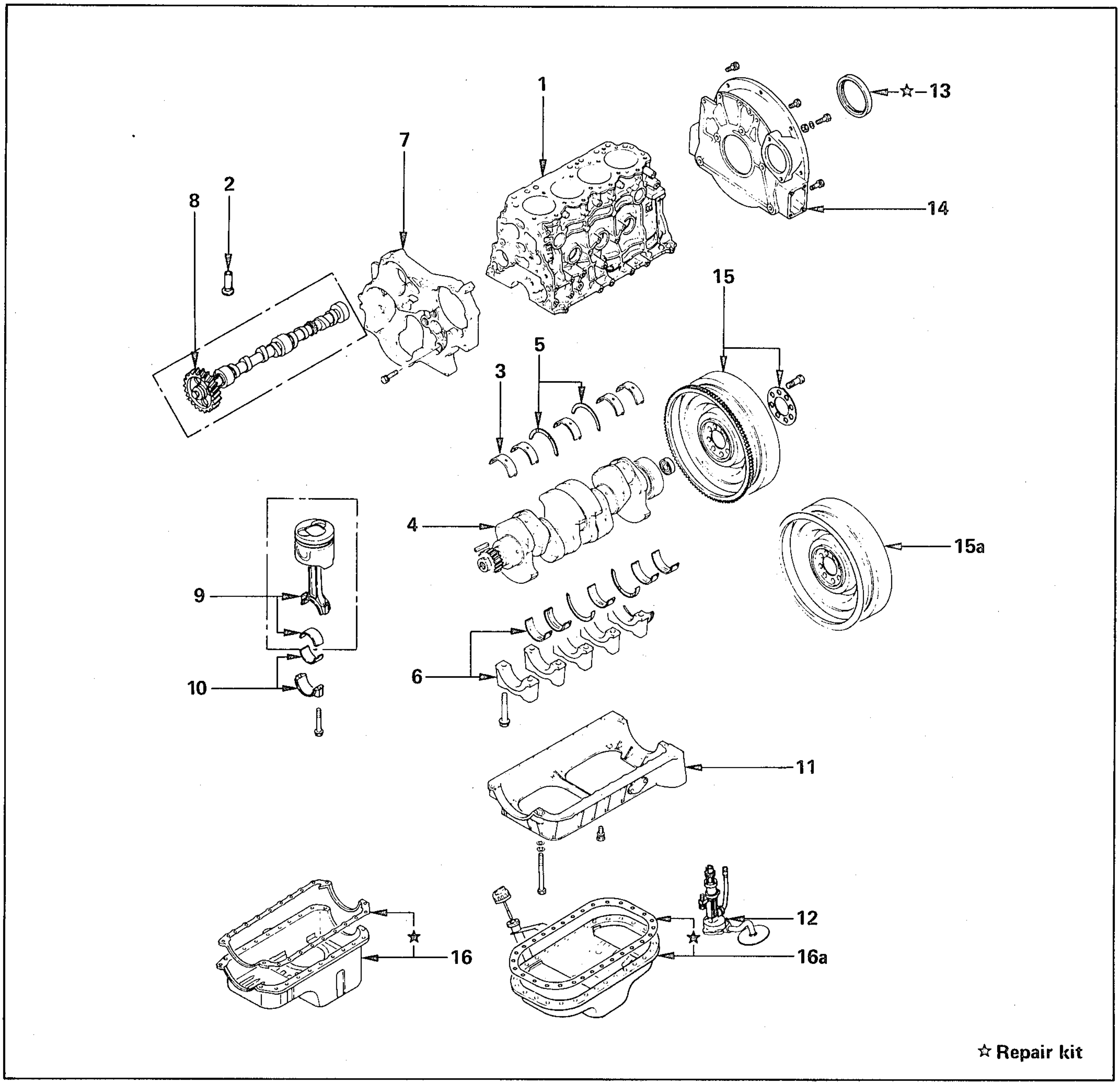
Camshaft Timing Gear Bolt Torque	kg·m(lb.ft/N·m)
11.0 ± 1.0 (79.5 ± 7.2/107.8 ± 9.8)	

MEMO

"QUALITY PARTS YOU CAN TRUST"


ISUZU
純正部品
GENUINE PART
ISUZU
純正部品
GENUINE PART

REASSEMBLY

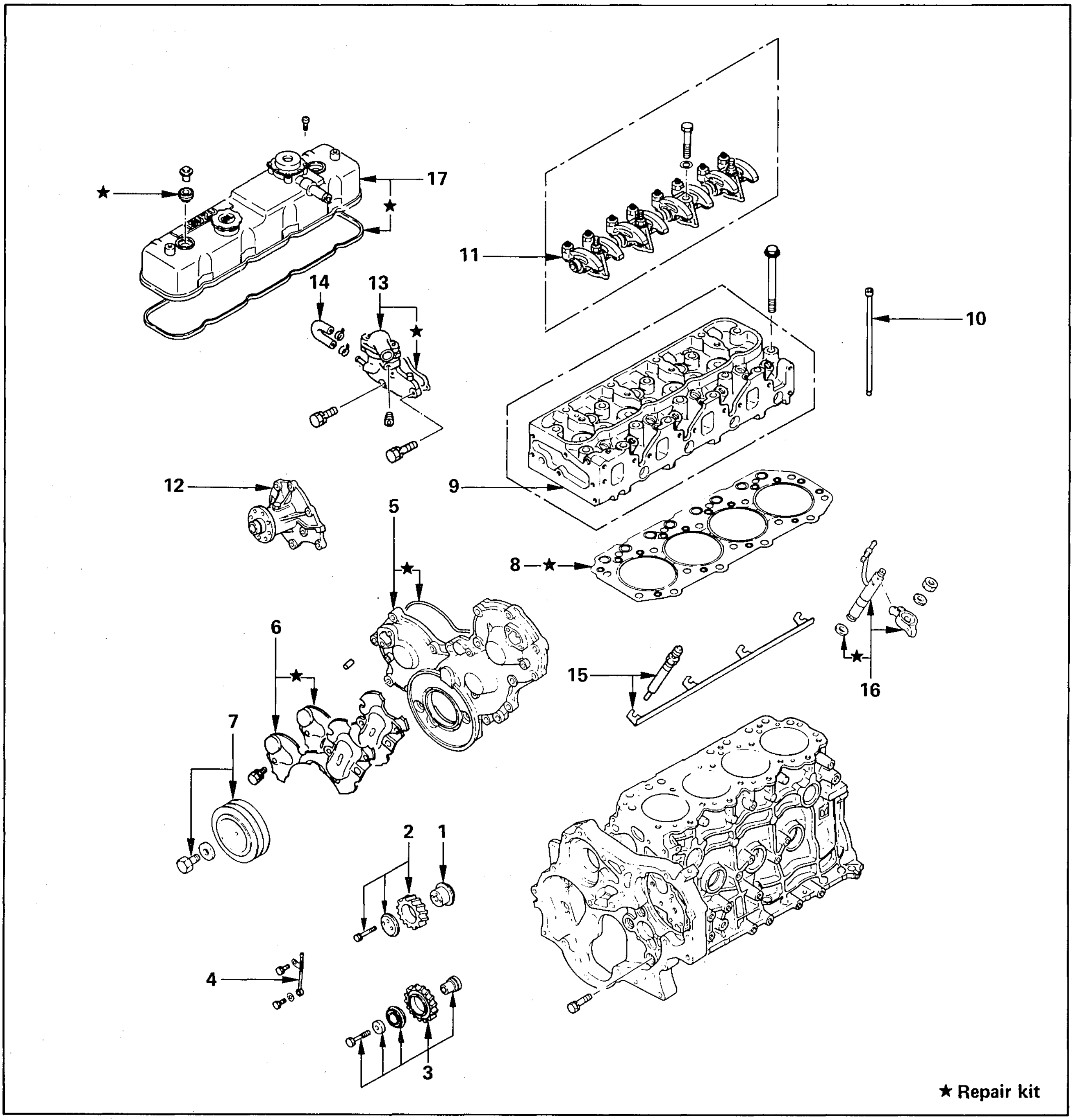


☆ Repair kit

Reassembly Steps – 1

▲ 1. Cylinder body
▲ 2. Tappet
▲ 3. Crankshaft upper bearing
▲ 4. Crankshaft with crankshaft timing gear
▲ 5. Crankshaft thrust bearing
▲ 6. Crahkshaft bearing cap with lower bearing
▲ 7. Timing gear case
▲ 8. Camshaft with camshaft timing gear and thrust plate
▲ 9. Piston and connecting rod with upper bearing
▲ 10. Connecting rod cap with lower bearing
▲ 11. Crankcase (If so equipped)
▲ 12. Oil pump with oil pipe
▲ 13. Crankshaft rear oil seal
▲ 14. Flywheel housing
▲ 15. Flywheel
15a Rear flywheel (If so equipped)
▲ 16. Oil pan
16a Oil pan (If so crankcase equipped)

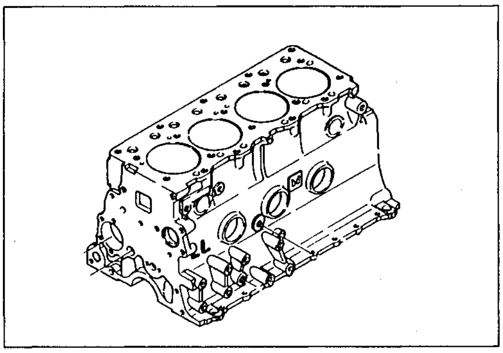
Inverted Engine



Reassembly Steps - 2

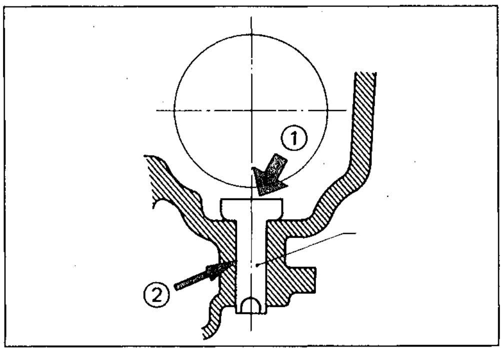
- ▲ 1. Idler gear shaft
- ▲ 2. Idler gear "A"
- ▲ 3. Idler gear "B"
- 4. Timing gear oil pipe
- ▲ 5. Timing case cover
- 6. Timing gear case cover
- ▲ 7. Crankshaft damper pulley with dust seal
- ▲ 8. Cylinder head gasket
- ▲ 9. Cylinder head
- 10. Push rod
- ▲ 11. Rocker arm shaft and rocker arm
- ▲ 12. Water pump
- ▲ 13. Thermostat housing
- 14. Water by-pass hose
- ▲ 15. Glow plug and glow plug connector seal
- ▲ 16. Injection nozzle holder
- 17. Cylinder head cover

Important Operations (Reassembly Steps-1)



1. Cylinder Body

Use compressed air to thoroughly clean the inside and outside surfaces of the cylinder body, the oil holes, and the water jackets.

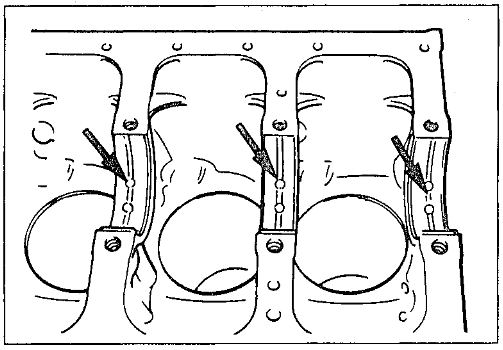


2. Tappet

1) Apply a coat of engine oil to the tappet ① and the cylinder body tappet insert holes ②.
2) Locate the position mark applied at disassembly (if the tappet is to be reused).

Note:

The tappet must be installed before the camshaft.



3. Crankshaft Upper Bearing

The crankshaft upper bearings have an oil hole and an oil groove. The lower bearings do not.

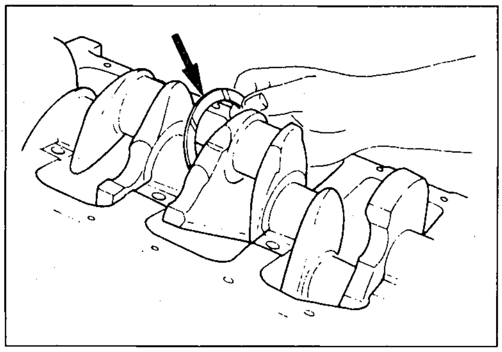
1) Carefully wipe any foreign material from the crankshaft upper bearing and the crankshaft upper bearing fitting surfaces.
2) Locate the position mark applied at disassembly if the removed crankshaft upper bearings are to be reused.

4. Crankshaft with Crankshaft Timing Gear

Apply an ample coat of engine oil to the crankshaft journals and the crankshaft bearing surfaces before installing the crankshaft.

Note:

Do not apply engine oil to the bearing back faces and the cylinder body bearing fitting surfaces.

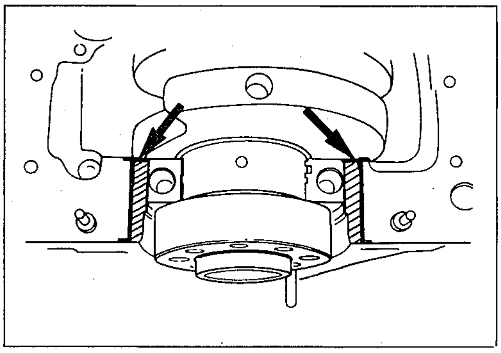


5. Crankshaft Thrust Bearing

1) Apply an ample coat of engine oil to the crankshaft thrust bearings.

2) Install the crankshaft thrust bearings to the crankshaft center journal.

The crankshaft thrust bearing oil groove must be facing the sliding face.



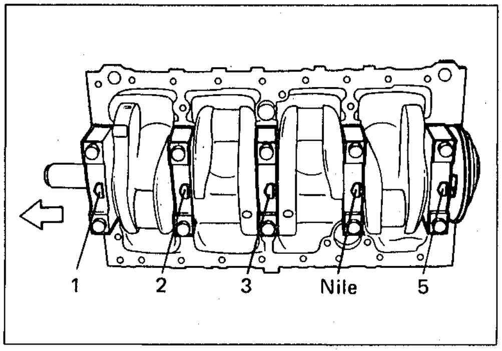
6. Crankshaft Bearing Cap with Lower Bearing

1) Apply silicon adhesive to the cylinder body No. 5 bearing cap fitting surface at the points shown in the illustration.

Note:

Be sure that the bearing cap fitting surface is completely free of oil before applying the silicon adhesive.

Do not allow the silicon adhesive to obstruct the cylinder thread holes and bearings.



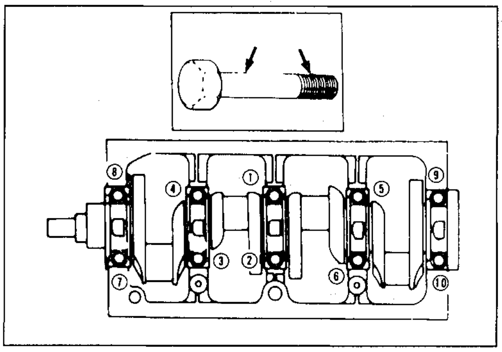
2) Install the bearing caps.

The bearing cap arrow marks must be facing the front of the engine.

The arrow mark journal number must correspond to the journal to which the bearing cap is installed.

Note:

The No. 4 journal bearing cap does not have a number stamped on it.

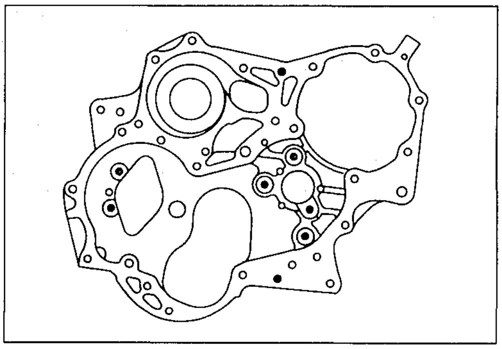


3) Apply a coat of engine oil to the bearing cap bolts.

4) Tighten the crankshaft bearing cap bolts to the specified torque a little at a time in the sequence shown in the illustration.

Crankshaft Bearing Cap Torque	kg·m(lb.ft/N·m)
17.0 ± 1.0 (123.0 ± 7.23/166.6 ± 9.8)	

5) Check to see that the crankshaft turns smoothly by rotating it manually.

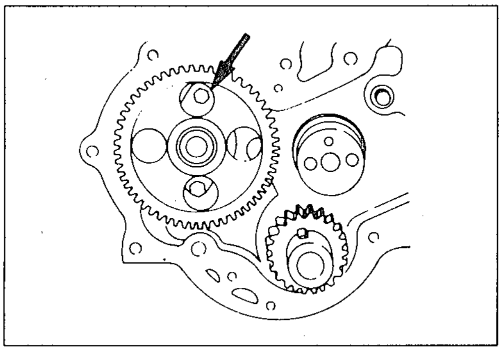


7. Timing Gear Case

1) Tighten the timing gear case with timing gear case gasket to the specified torque.

Timing Gear Case Bolt Torque	kg·m(lb.ft/N·m)
1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)	

2) Cut away any excessive flash from the timing gear gasket.



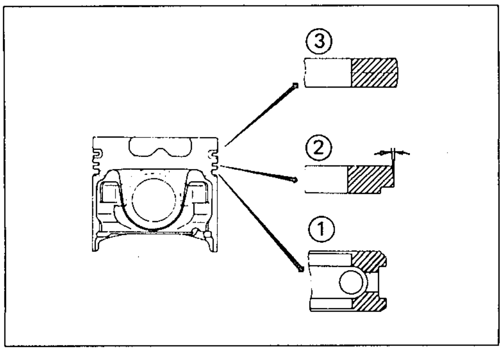
8. Camshaft with Camshaft Timing Gear and Thrust Plate

1) Apply a coat of engine oil to the camshaft and the camshaft bearings.
2) Install the camshaft to the cylinder body.

   Take care not to damage the camshaft bearings.
3) Tighten the thrust plate to the specified torque.

Thrust Plate Bolt Torque	kg·m(lb.ft/N·m)
1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)	

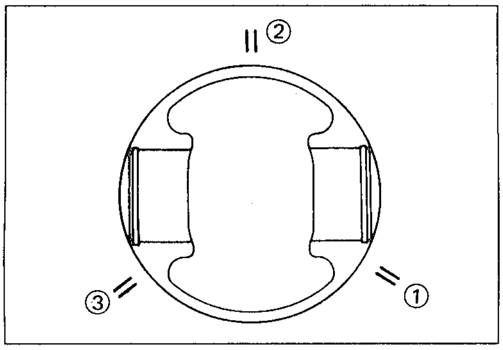
4) Check to see that the camshaft turns smoothly by rotating it manually.



9. Piston and Connecting Rod with Upper Bearing

10. Connecting Rod Bearing Cap with Lower Bearing

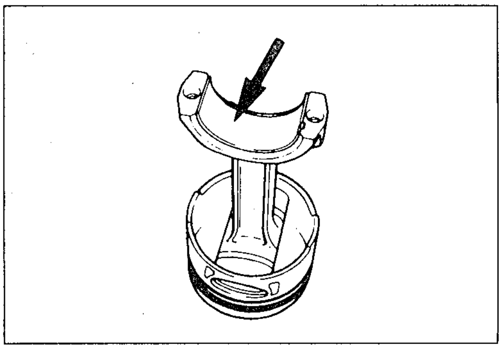
1) Apply a coat of engine oil to the circumference of each piston ring and piston.



2) Position the piston ring gaps as shown in the illustration.

   ① 1st compression ring
   ② 2nd compression ring
   ③ Oil ring
3) Apply a coat of molybdenum disulfide grease to the two piston skirts.

   This will faciliate smooth break-in when the engine is first started after reassembly.

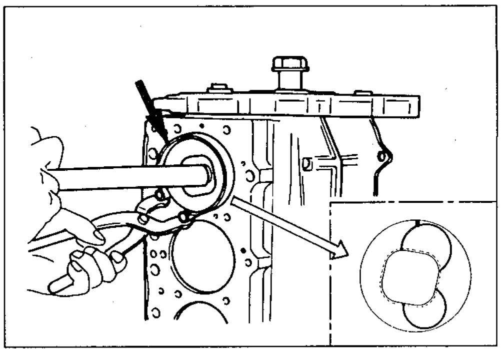


4) Apply a coat of engine oil to the upper bearing surfaces.

Note:

Do not apply engine oil to the bearing back faces and the connecting rod bearing fitting surfaces.

5) Apply a coat of engine oil to the cylinder wall.



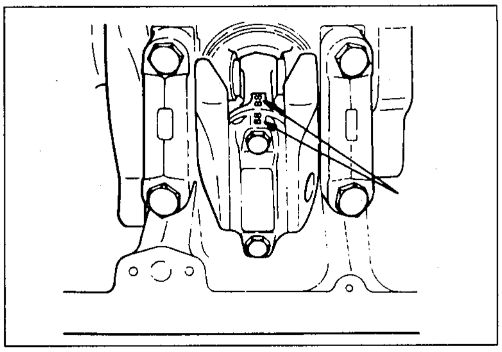
6) Position the piston head front mark so that it is facing the front of the cylinder body.

7) Use a piston ring compressor to compress the piston rings.

   Piston Ring Compressor

8) Use a hammer grip to push the piston in until the connecting rod makes contact with the crankpin.

   At the same time, rotate the crankshaft until the crankpin is at BDC.



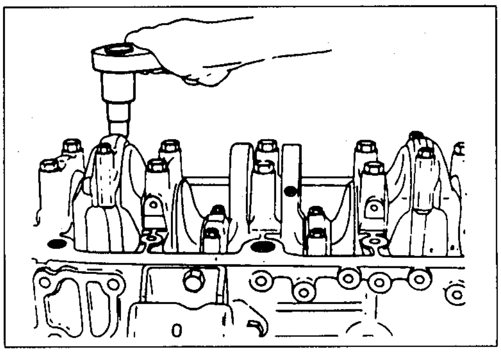
9) Install the connecting rod bearing caps.

   The bearing cap front marks must be facing the front of the engine.

   The bearing cap number (at the side of the bearing cap) and the connecting rod number must be the same.

Note:

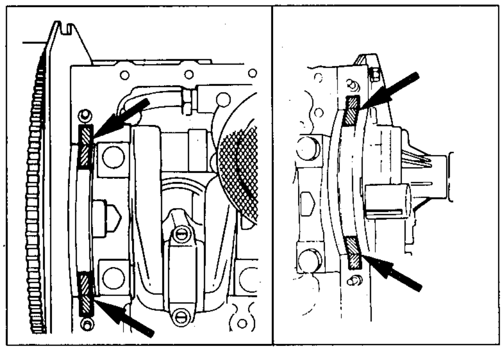
It is absolutely essential that the bearing caps be installed in the correct direction. Reversing the bearing cap direction will result in serious engine damage.



10) Apply a coat of engine oil to the threads and setting faces of each connecting rod cap bolt.

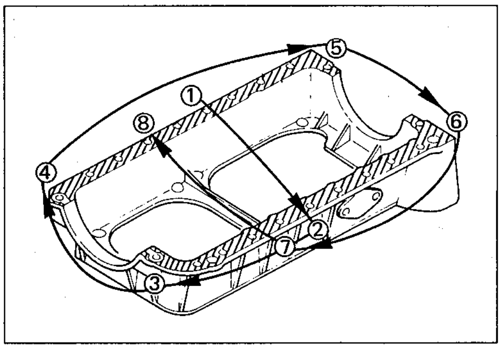
11) Tighten the connecting rod caps to the specified torque.

Connecting Rod Cap Bolt Torque kg·m(lb.ft/N·m)
8.5 ± 0.5 (61.5 ± 3.6/83.3 ± 4.9)



11. Crankcase (if so equipped)

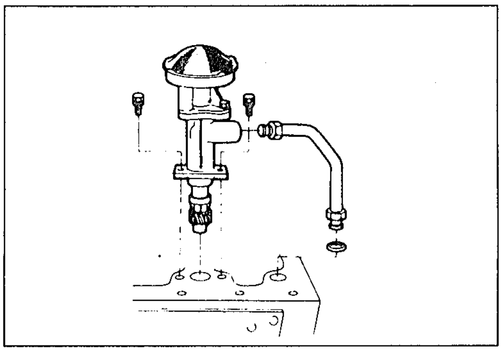
1) Apply liquid gasket to the No. 5 bearing cap arches, the bearing grooves, and the timing gear case arches at the positions shown in the illustration.



2) Apply liquid gasket to the crankcase cylinder body fitting area.

3) Tighten the crankcase bolts to the specified torque a little at a time in the sequence shown in the illustration.

Crankcase Bolt Torque kg·m(lb.ft/N·m)
1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)



12. Oil Pump with Oil Pipe

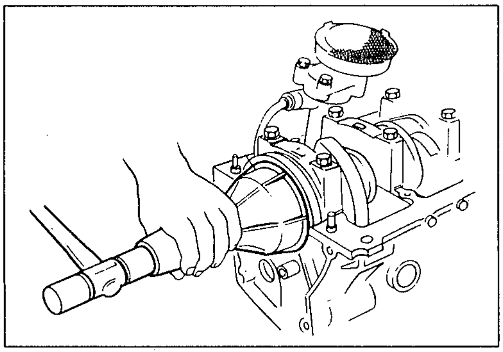
Install the oil pump with the oil pipe and tighten the bolts to the specified torque.

Oil Pump Bolt Torque kg·m(lb.ft/N·m)

1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)

Note:

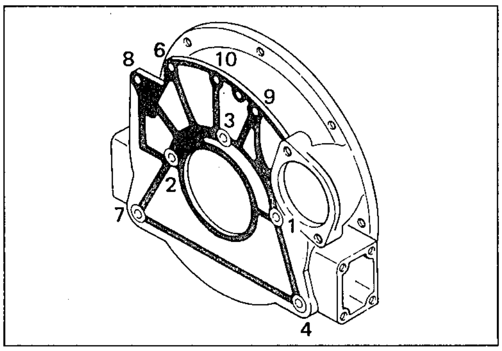
Take care not to damage the O-rings when tightening the oil pipe bolts.



13. Crankshaft Rear Oil Seal

1) Apply engine oil to the oil seal lip circumference and the oil seal outer circumference.
2) Use the oil seal installer to install the oil seal to the cylinder body.

   Oil Seal Installwe: 5-8840-0141-0

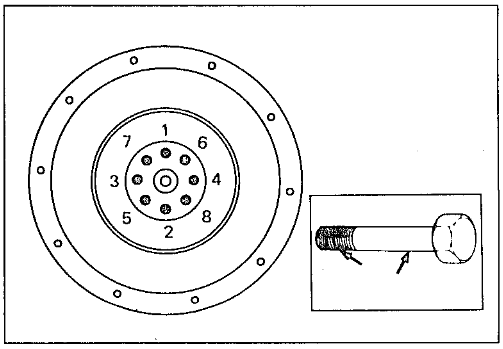


14. Flywheel Housing

1) Apply liquid gasket to the shaded area shown in the illustration.
2) Tighten the flywheel housing bolts to the specified torque a little at a time in the sequence shown in the illustration.

Flywheel Housing Bolt Torque kg·m(lb.ft/N·m)

M10×1.25 (0.40×0.05) Bolt	5.6±1.0 (40.5±7.2/ 54.9±9.8)
M12×1.25 (0.47×0.05) Bolt	10.5±1.0 (76.0±7.2/103.0±9.8)
M12×1.75 (0.47×0.07) Bolt	9.8±1.0 (71.0±7.2/ 96.0±9.8)



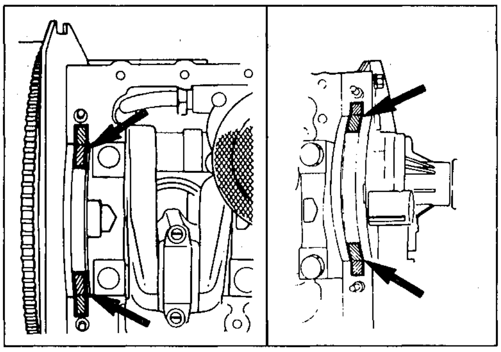
15. Flywheel

1) Block the flywheel with a piece of wood to prevent it from turning.
2) Apply a coat of engine oil to the threads of the flywheel bolts.
3) Tighten the flywheel bolts in the numerical order shown in the illustration.

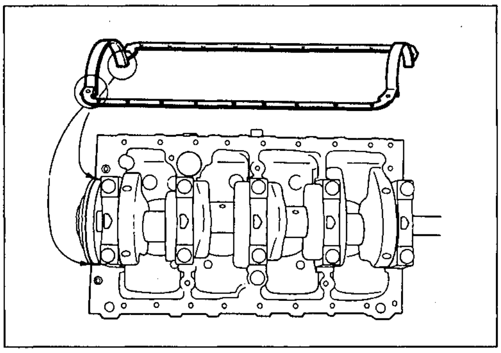
Flywheel Bolt Torque kg·m(lb.ft/N·m)

12.0 ± 0.5 (86.8 ± 3.6/117.6 ± 4.9)

16. Oil Pan

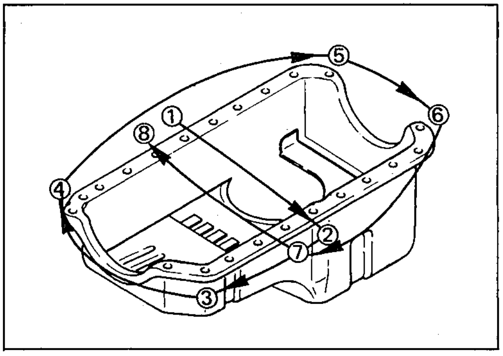


1) Apply liquid gasket to the No. 5 bearing cap arches, the bearing grooves, and the timing gear case arches at the positions shown in the illustration.



2) Fit the gasket rear lipped portion into the No. 5 bearing cap groove.

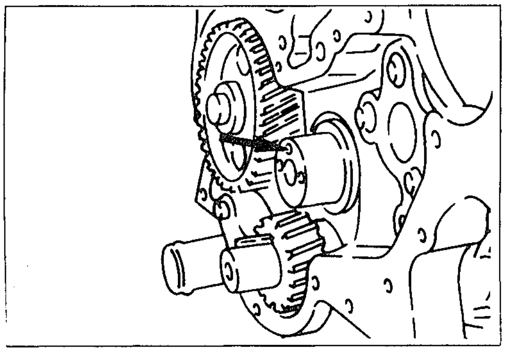
   Be absolutely sure that the lipped portion is fitted snugly in the groove.



3) Tighten the oil pan bolts to the specified torque a little at a time in the sequence shown in the illustration.

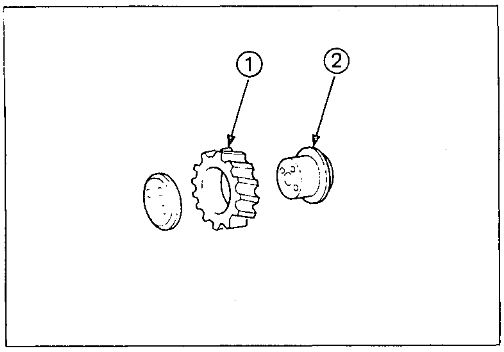
Oil Pan Bolt Torque	kg·m(lb.ft/N·m)
1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)	

Important Operations (Reassembly Steps-2)



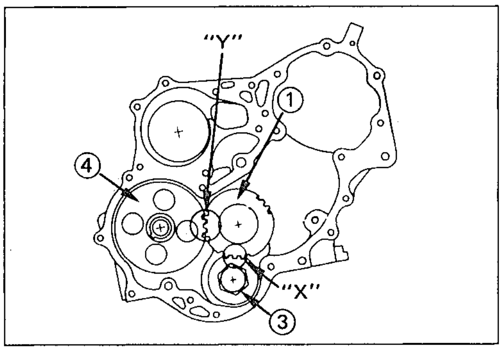
1. Idler Gear Shaft

The idler gear shaft oil hole must be facing up.



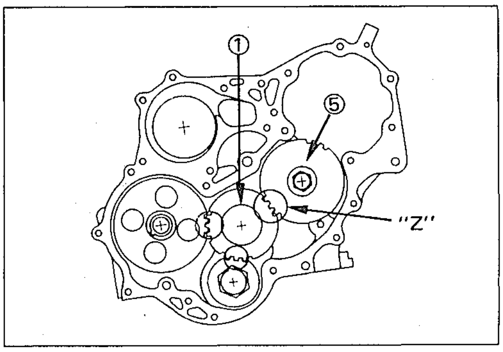
2. Idler Gear "A"

1) Apply engine oil to the idler gear ① and the idler gear shaft ②.
2) Position the idler gear setting marks "X" and "Y" so that they are facing the front of the engine.



3) Align the idler gear "X" setting mark with the crankshaft timing gear ③ "X—X" setting mark.
4) Align the idler gear "Y" setting mark with the camshaft timing gear ④ "Y—Y" setting mark.
5) Tighten the idler gear bolt to the specified torque.

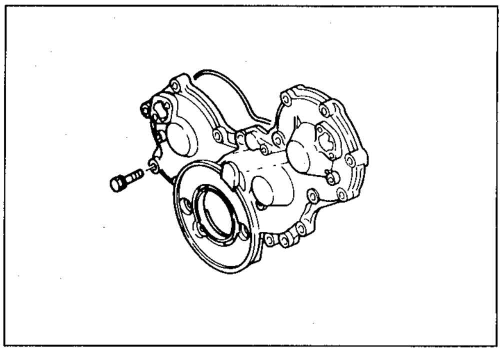
Idler Gear "A" Bolt Torque	kg·m(lb.ft/N·m)
1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)	

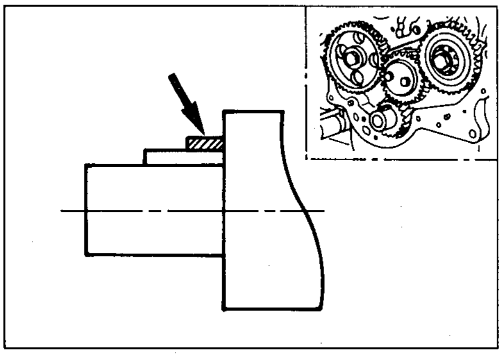


3. Idler Gear "B"

1) Apply engine oil to the idler gear and the idler gear shaft.
2) Align the idler gear ⑤ "Z" setting mark with the idler gear ① "Z" setting mark.

Idler Gear "B" Bolt Torque	kg·m(lb.ft/N·m)
11.0 ± 1.0 (79.5 ± 7.2/107.8 ± 9.8)	





5. Timing Case Cover

1) Before installing the timing gear case, apply a 3 mm × 5 mm (0.12 in × 0.20 in) strip of liquid gasket to the portion of the feather key indicated by the arrow in the illustration.

2) Check that the timing case cover O-ring is firmly inserted into the gear case groove.

3) Tighten the timing case cover bolts to the specified torque.

Timing Case Cover Bolt Torque kg·m(lb.ft/N·m)

M 8×1.25 (0.31×0.05) Bolt	1.9±0.5 (13.7±3.6/18.6±4.9)
M12×1.25 (0.47×0.05) Bolt	7.7±1.0 (55.7±7.2/75.5±9.8)

7. Crankshaft Damper Pully with Dust Seal

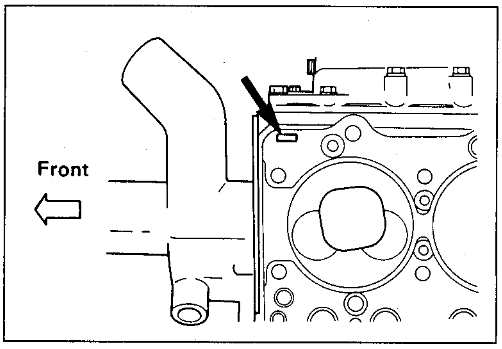
1) Block the flywheel ring gear with a piece of wood to prevent it from turning.

2) Tighten the crankshaft damper pulley to the specified torque.

Crankshaft Damper Pulley Bolt
Torque kg·m(lb.ft/N·m)

19.0 ± 2.0 (137.4 ± 14.5/186.2 ± 19.6)

Take care not to damage the crankshaft damper pulley boss.



8. Cylinder Head Gasket

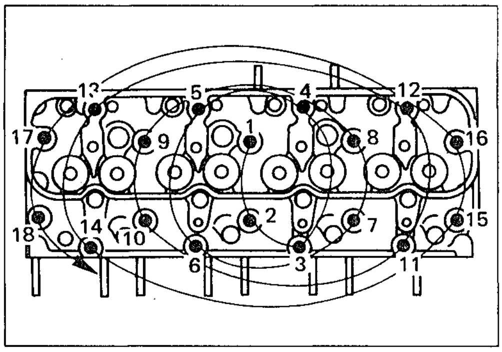
The cylinder gasket "TOP" mark must be facing up.

9. Cylinder Head

1) Align the cylinder body dowels and the cylinder head dowel holes.

   Carefully set the cylinder head to the cylinder head gasket.

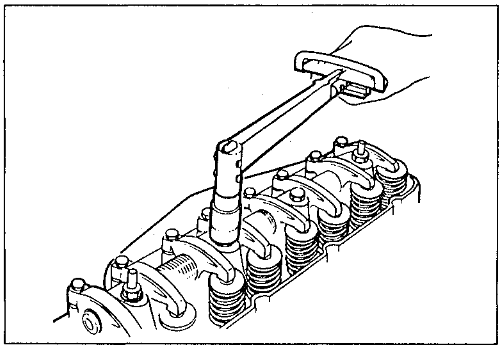
2) Apply engine oil to the cylinder head fixing bolt threads and setting faces.



3) Tighten the cylinder head bolts to the specified torque in two steps following the numerical order shown in the illustration.

Cylinder Head Bolt Torque kg·m(lb.ft/N·m)

	1st Step	2nd Step
New Bolt	4.0±1.0 (28.9±7.2/39.0±9.8)	8.7±0.5 (63.0±3.6/85.3±4.9)
Reused Bolt	8.5±0.5 (61.5±3.6/83.3±4.9)	10.5±0.5 (76.0±3.6/103.0±4.9)

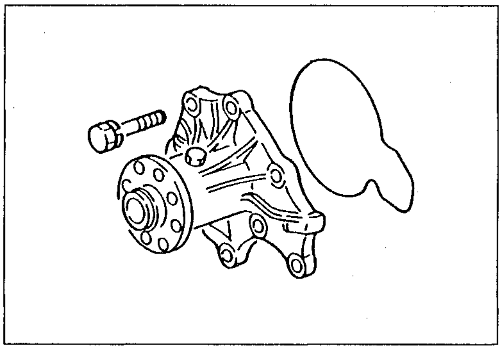


11. Rocker Arm Shaft and Rocker Arm

Tighten the rocker arm shaft bracket bolts in the numerical order shown in the illustration.

Rocker Arm Shaft Bracket Bolt Torque kg·m(lb.ft/N·m)

5.5 ± 0.5 (37.8 ± 3.6/53.9 ± 4.9)



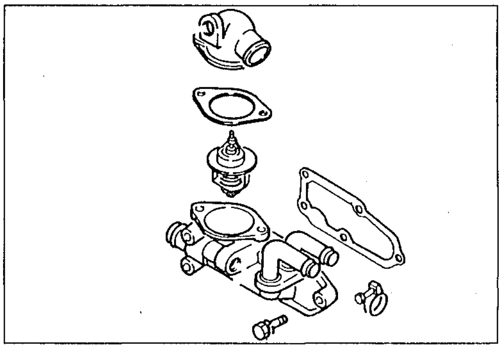
12. Water Pump

1) Temporarily tighten the water pump bolt marked with an arrow in the illustration.
   This bolt will be tightened to the specified to torque when the alternator adjusting plate is installed.

2) Tighten the other water pump bolts to the specified torque.

Water Pump Bolt Torque kg·m(lb.ft/N·m)

1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)



13. Thermostat Housing

1) Install the thermostat housing.

2) Tighten the thermostat housing bolts to the specified torque.

Thermostat Housing Bolt Torque kg·m(lb.ft/N·m)

1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)

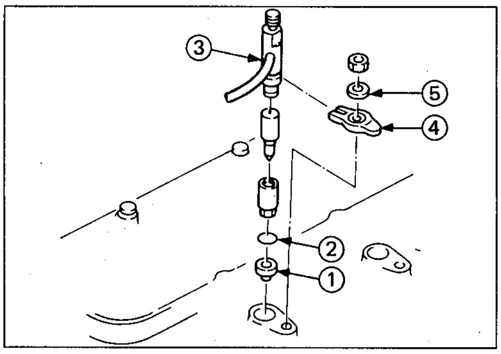
15. Glow Plug and Glow Plug Connector

1) Tighten the glow plugs to the specified torque.

Glow Plug Torque kg·m(lb.ft/N·m)

2.25 ± 0.25 (16.3 ± 1.8/22.1 ± 2.5)

2) Install the glow plug connectors.

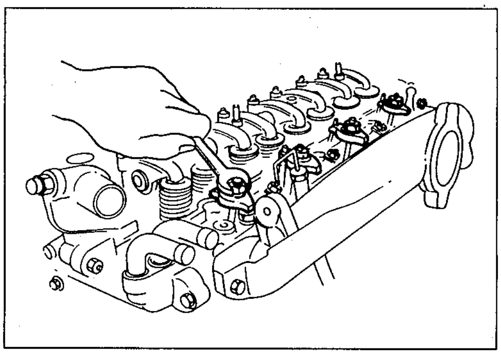


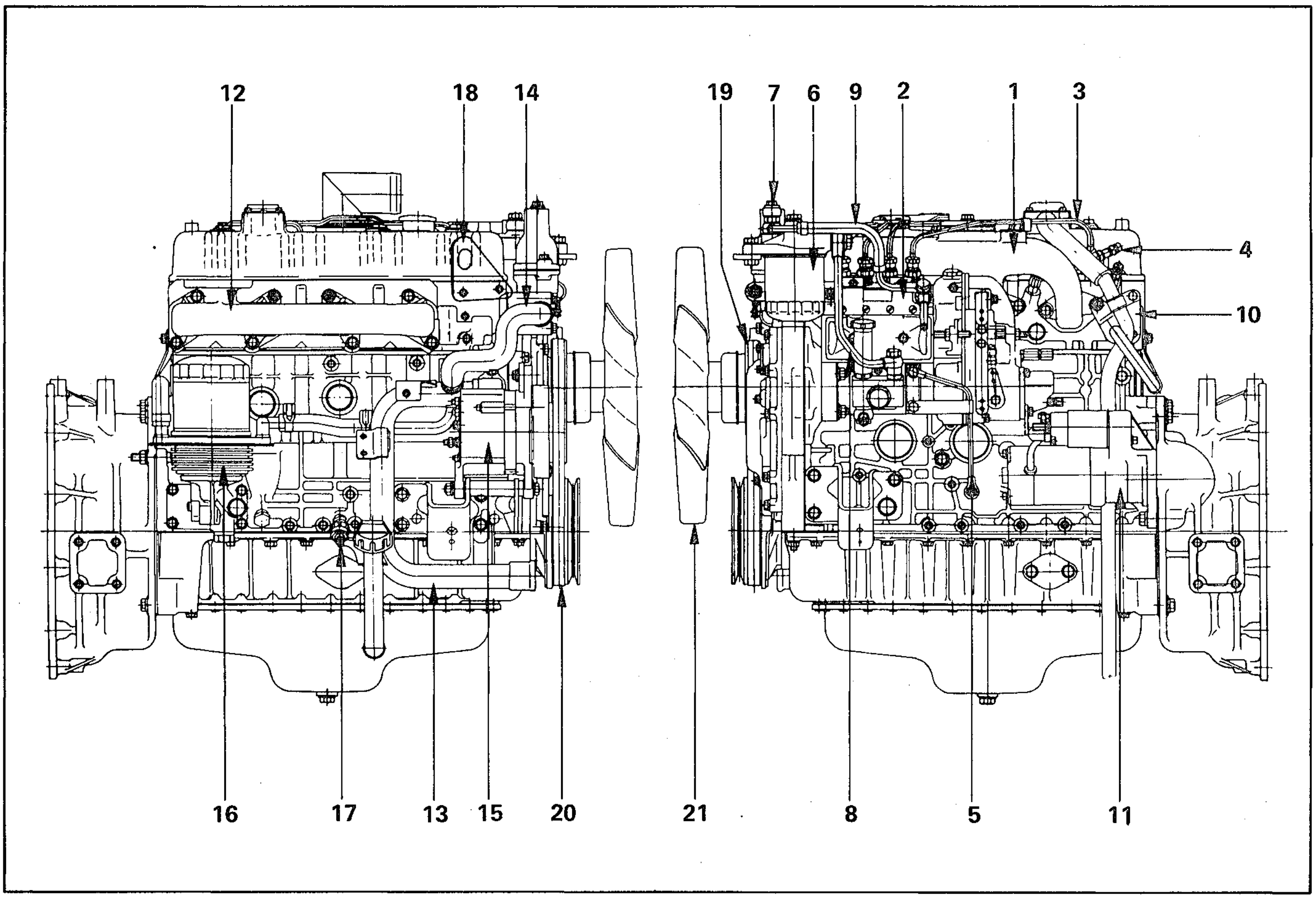
16. Injection Nozzle Holder

1) Install the injection nozzle gasket ① and the O-ring ② to the injection nozzle holder ③.
2) Install the nozzle holder ③ together with the nozzle holder bracket ④ to the cylinder head.
3) Tighten the holder nuts with washer ⑤ to the specified torque.

Injection Nozzle Holder Nut Torque kg·m(lb.ft/N·m)

3.8 ± 0.6 (26.0 ± 4.3/37.2 ± 5.9)

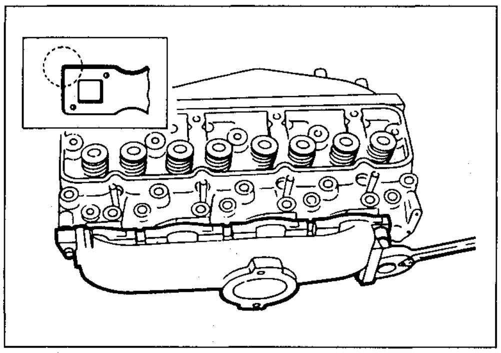




Reassembly Steps - 3

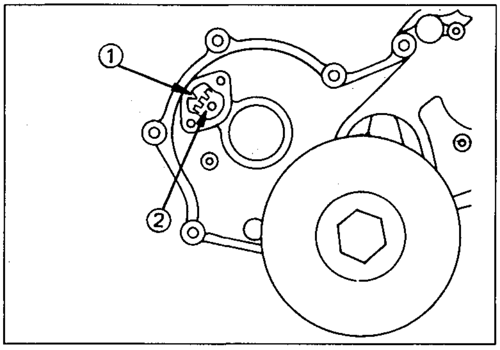
- ▲ 1. Intake manifold
- ▲ 2. Injection pump
- ▲ 3. Fuel injection pump with clip
- 4. Fuel leak off pipe
- 5. Oil pipe (Injection pump to cylinder body)
- 6. Fuel filter
- 7. Fuel pipe (Fuel filter to leak off)
- 8. Fuel pipe (Fuel filter to feed pump)
- 9. Fuel pipe (Fuel filter to injection pump)
- 10. Rear engine hanger
- ▲ 11. Starter
- ▲ 12. Exhaust manifold
- 13. Cooling water intake pipe
- 14. Cooling water rubber hose
- ▲ 15. Alternator and adjusting plate
- ▲ 16. Oil filter
- 17. Oil pressure switch
- 18. Front engine hanger
- 19. Cooling fan drive pulley
- 20. Cooling fan drive belt
- 21. Cooling fan and spacer

Important Operations (Reassembly Steps-3)



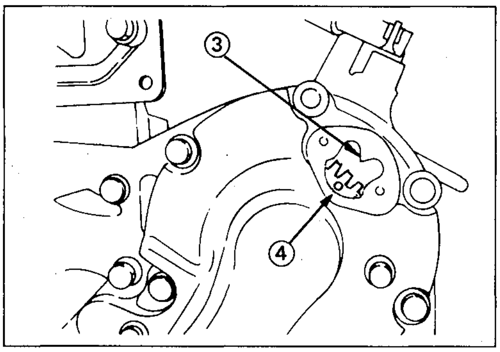
1. Intake Manifold

Install the intake manifold gasket with the end having the sharp corners facing the front of the engine.



2. Injection Pump

1) Turn the crankshaft slowly clockwise to align the camshaft timing check hole pointer ① with the camshaft timing gear "O" mark ②.

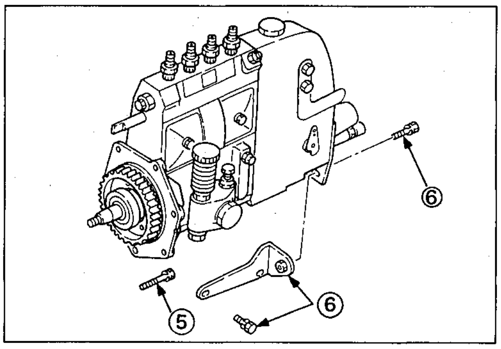


2) Install the injection pump to the timing gear case.

   Align the injection pump timing check hole pointer ③ with the timing gear "O" mark ④.

3) Temporarily tighten the injection pump bracket bolt ⑤.

   This bolt will be finally tightened after the injection pump rear bracket bolts ⑥.



4) Tighten the injection pump rear bracket bolts to the specified torque ⑥.

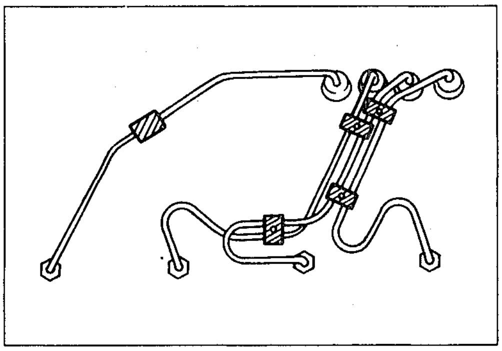
Injection Pump Rear Bracket Bolt Torque kg·m(lb.ft/N·m)

1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)

5) Tighten the injection pump bracket bolt ⑤ to the specified torque.

Injection Pump Bracket Bolt Torque kg·m(lb.ft/N·m)

1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)



3. Fuel Injection Pipe with Clip

1) Temporarily tighten the injection pipe sleeve nut.

2) Set the clip in the prescribed position.

Note:

Make absolutely sure that the clip is correctly positioned.

An improperly positioned clip will result in injection pipe breakage and fuel pulsing noise.

3) Tighten the injection pipe sleeve nut to the specified torque.

Injection Pipe Sleeve Nut Torque kg·m(lb.ft/N·m)

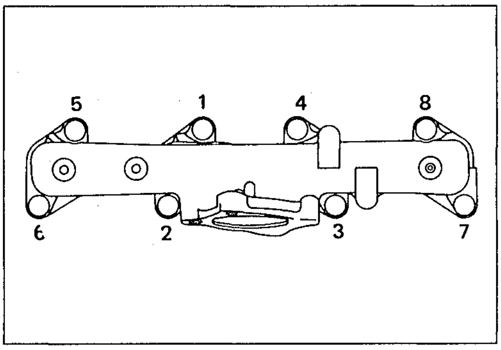
3.0 ± 1.2 (21.7 ± 8.7/29.4 ± 11.8)

11. Starter

Tighten the starter bolts to the specified torque.

Starter Bolt Torque kg·m(lb.ft/N·m)

7.0 ± 1.0 (50.6 ± 7.2/68.6 ± 9.8)



12. Exhaust Manifold

Tighten the exhaust manifold bolts to the specified torque a little at a time in the numerical order shown in the illustration.

Exhaust Manifold Bolt Torque kg·m(lb.ft/N·m)

1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)

15. Alternator and Adjusting Plate

Tighten the alternator bolts and the adjusting plate bolts to the specified torque.

Alternator Bolt Torque kg·m(lb.ft/N·m)

4.1 ± 0.5 (29.6 ± 4.3/40.2 ± 4.9)

Tighten the adjusting plate bolts to the specified torque after cooling drive belt installation.

Adjusting Plate Bolt Torque kg·m(lb.ft/N·m)

1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)

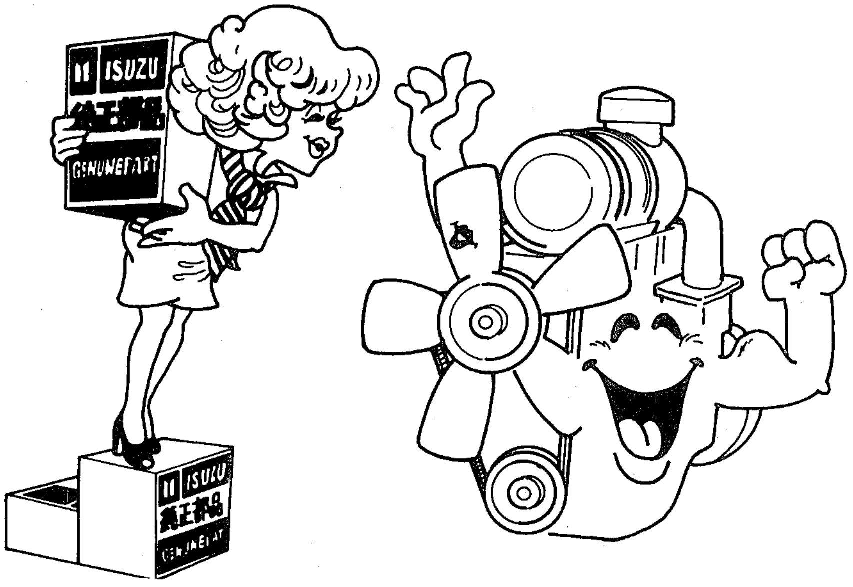
19. Oil Filter

Tighten the oil filter bolts to the specified torque.

Oil Filter Bolt Torque kg·m(lb.ft/N·m)

1.9 ± 0.5 (13.7 ± 3.6/18.6 ± 4.9)

MEMO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SECTION 6

LUBRICATING SYSTEM

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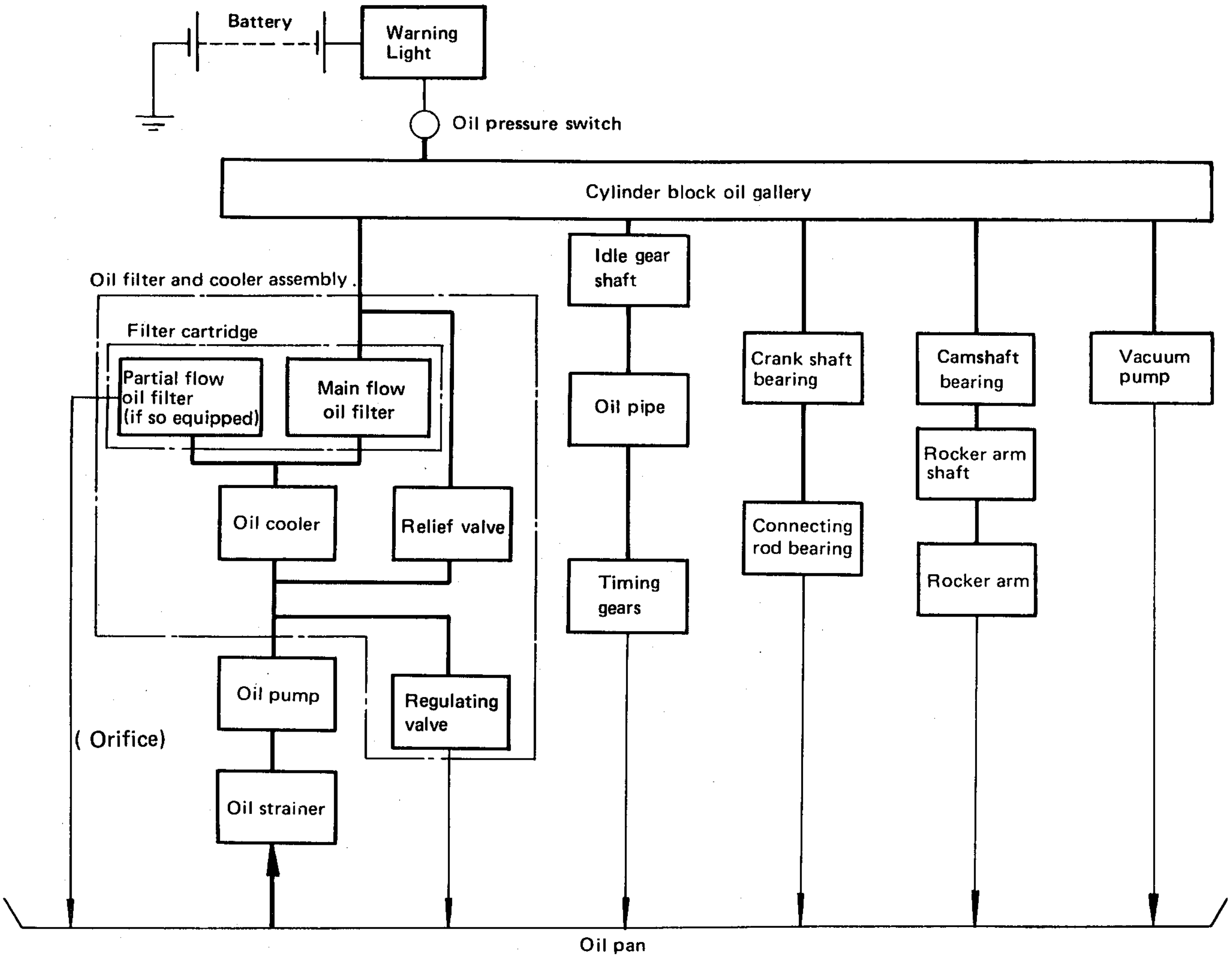
Main data and specifications .... 6— 2
General description .... 6— 3
Oil pump .... 6— 6
Oil filter with built-in oil cooler .... 6—12

MAIN DATA AND SPECIFICATIONS

Item		4JA1 · 4JB1 · 4JC1
Oil pump type		Trochoid
Delivery volume	Lit(US/UK gal)/min.	17.5 (4.61/3.85)
Pump speed		1000
Delivery pressure	kg/cm^2(psi/kPa)	4.0 (56.89/392.0)
Oil temperature	°C(°F)	47 — 53 (116.6 — 127.4)
Engine oil		SAE 30
Oil filter type		Full flow with cartridge paper element
Relief valve opening pressure	kg/cm^2(psi/kPa)	4.3 — 4.7 (61.14 — 66.83/421.4 — 460.6)
Safety valve opening pressure	kg/cm^2(psi/kPa)	0.8 — 1.2 (11.38 — 17.07/78.9 — 117.6)
Oil cooler type (if so equipped)		Water-cooled
Safety valve opening pressure	kg/cm^2(psi/kPa)	2.3 — 2.7 (32.70 — 38.40/225.4 — 264.6)

GENERAL DESCRIPTION

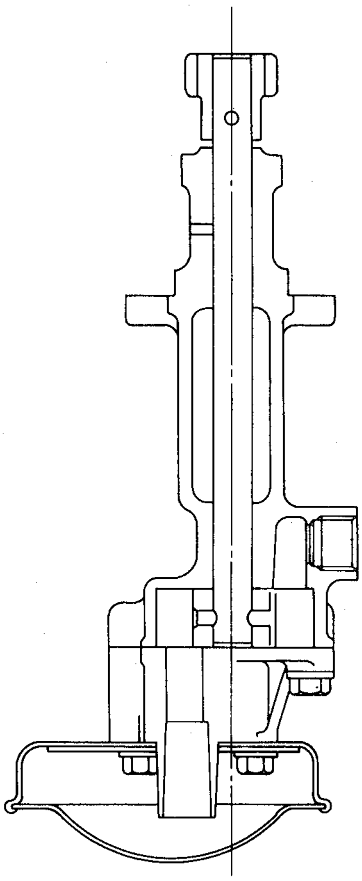
LUBRICATING OIL FLOW


Battery
Warning Light
Oil pressure switch
Cylinder block oil gallery
Oil filter and cooler assembly
Filter cartridge
Partial flow oil filter (if so equipped)
Main flow oil filter
Oil cooler
Relief valve
Oil pump
Regulating valve
Oil strainer
(Orifice)
Idle gear shaft
Oil pipe
Timing gears
Crank shaft bearing
Connecting rod bearing
Camshaft bearing
Rocker arm shaft
Rocker arm
Vacuum pump
Oil pan

The 4J Series engine lubricating system is a full flow type.

Lubricating oil is pumped from the oil pump to the cylinder body oil gallery through the oil cooler and the oil filter. It is then delivered to the vital parts of the engine from the cylinder body oil gallery.

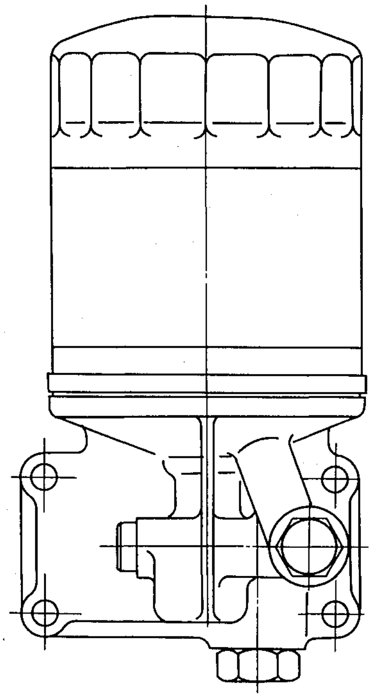
OIL PUMP



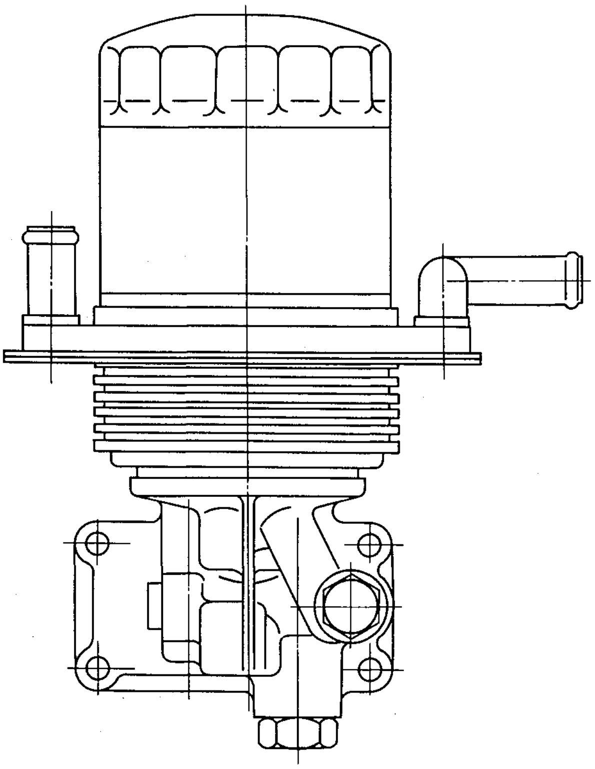
4J Series engine are equipped with a trochoid type oil pump.

The oil filter and the water cooled oil cooler are a single unit to increase the cooling effect.

MAIN OIL FILTER

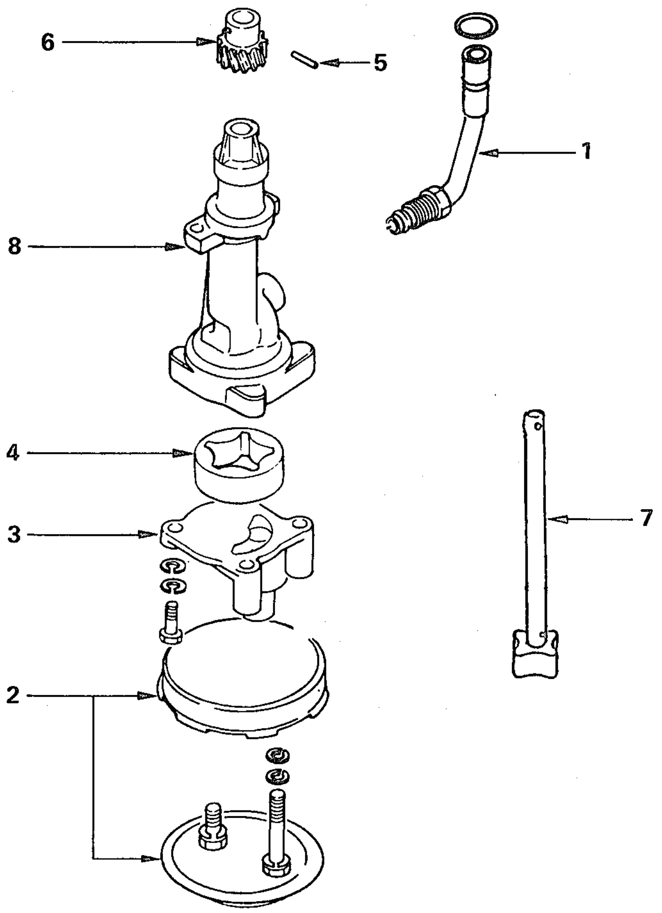


OIL FILTER WITH BUILT-IN OIL COOLER



OIL PUMP

DISASSEMBLY



Desassembly Steps

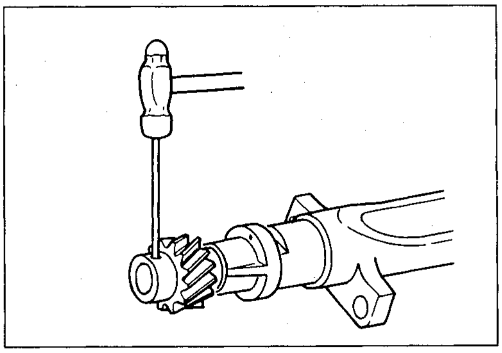
1. Oil pipe
2. Strainer case
3. Pump cover
4. Vane

▲ 5. Pinion pin

▲ 6. Pinion

7. Rotor drive shaft
8. Pump body

Important Operations



5. Pinion Pin

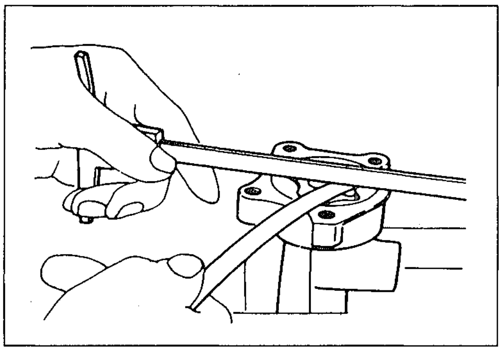
6. Pinion

File off caulked end of the pinion stopper pin, then drive out the pin toward the opposite side.

It is necessary to drill a hole in one side of the pinion for service as it does not have a hole on both sides.

INSPECTION AND REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



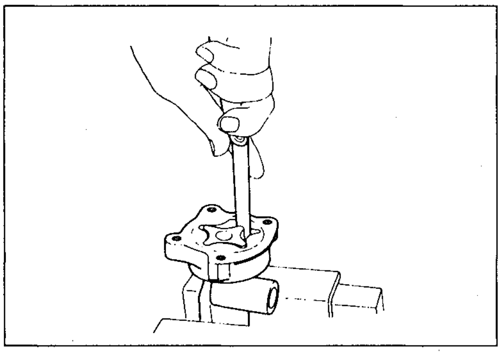
Vane, Rotor, and Cover Clearance

Use a feeler gauge to measure the clearance between the vane, the rotor, and the cover.

If the clearance between the vane, the rotor, and the cover exceeds the specified limit, the rotor set (pin, shaft, rotor, and vane) must be replaced.

Vane, Rotor, and Cover Clearance mm(in)

Standard	Limit
0.02—0.07 (0.0008—0.0026)	0.15 (0.006)



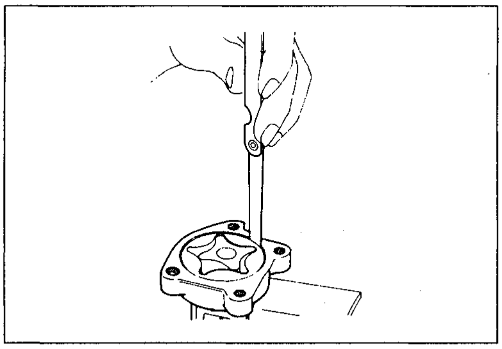
Rotor and Vane Clearance

Use a feeler gauge to measure the clearance between the rotor and the vane.

If the clearance between the rotor and the vane exceeds the specified limit, the rotor set (pin, shaft, rotor, and vane) must be replaced.

Rotor and Vane Clearance mm(in)

Standard	Limit
0.14—(0.006) or less	0.20 (0.008)



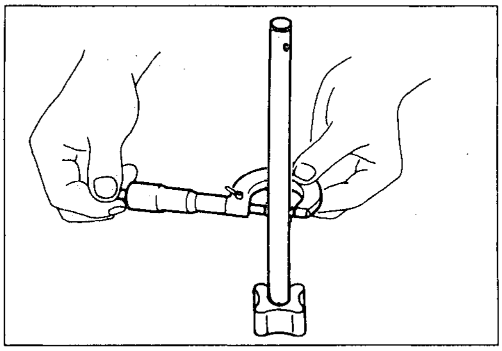
Vane and Pump Body Clearance

Use a feeler gauge to measure the clearance between the vane and the pump body.

If the clearance between the vane and the pump body exceeds the specified limit, the entire pump assembly must be replaced.

Vane and Pump Body Clearance mm(in)

Standard	Limit
0.20—0.27 (0.008—0.011)	0.40 (0.016)

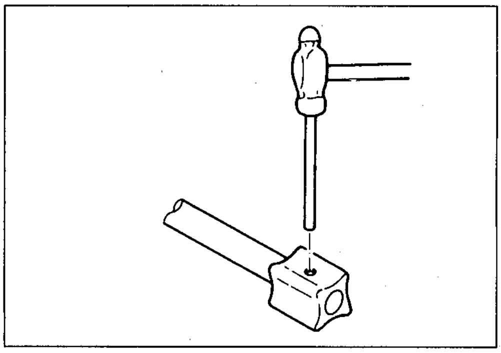


Rotor Drive Shaft and Oil Pump Body Clearance

Use a micrometer to measure the rotor shaft outside diameter.
Use an inside dial indicator to measure the pump body inside diameter.
If the clearance between the rotor shaft and the pump body exceeds the specified limit, the entire pump assembly must be replaced.

Rotor Shaft and Pump Body Clearance mm(in)

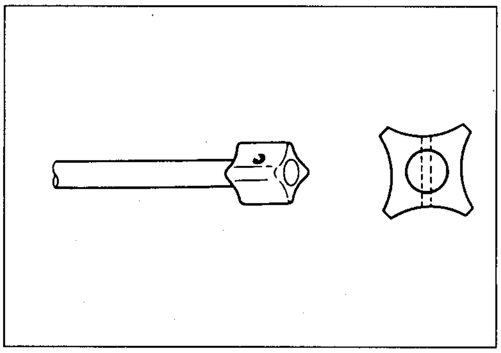
Standard	Limit
0.04 (0.0016)	0.20 (0.008)



Rotor Replacement

Rotor Removal

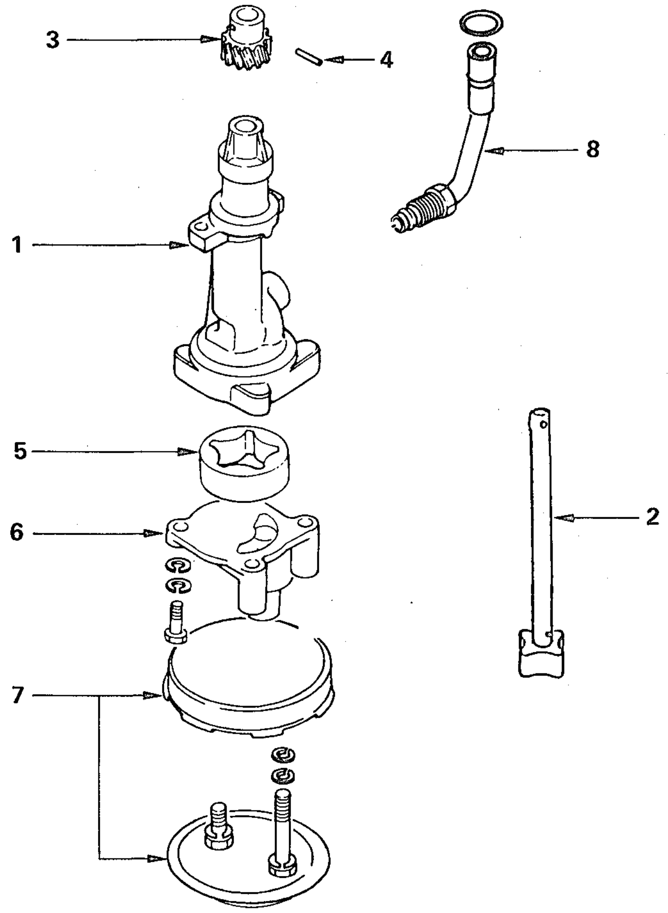
Drive out the pin from one side.



Rotor Installation

When the pin is installed, check to make certain end of the pin is not project from the end of rotor.

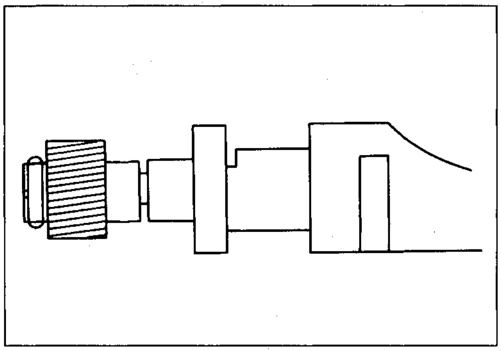
REASSEMBLY



Reassembly Steps

1. Pump body
2. Rotor drive shaft
3. Vane
4. ▲ Pinion
5. ▲ Pinion pin
6. Pump cover
7. Strainer case
8. Oil pipe

Important Operations



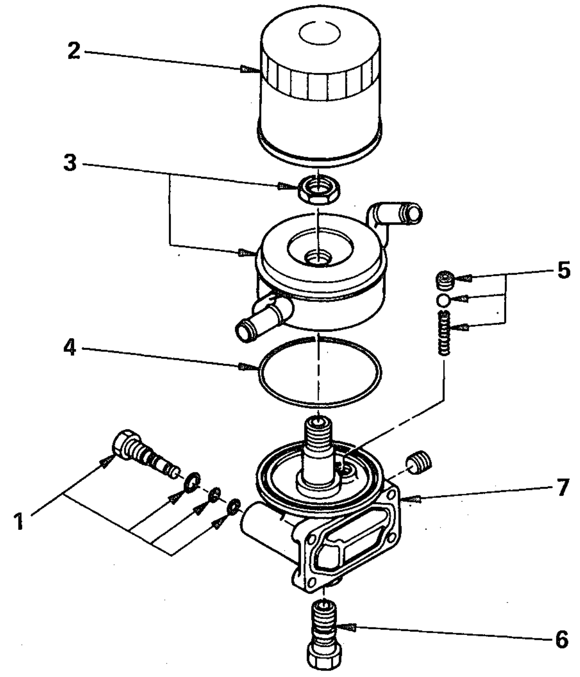
4. Pinion

5. Pinion Pin

1) Install the new rotor shaft to the pump body.
2) Set the pinion to the rotor shaft.
3) Use a 5 mm (0.20 in) drill to drill a hole through the pinion and the rotor shaft.
4) Insert the pin into the hole.
5) Caulk the pin.

OIL FILTER WITH BUILT-IN OIL COOLER

DISASSEMBLY

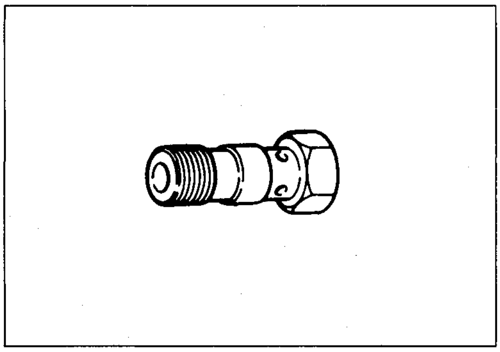


Desassembly Steps

1. Drain plug
2. Cartridge oil filter
3. Oil cooler
4. O-ring
5. Safety valve
6. Relief valve
7. Oil filter body

INSPECTION AND REPAIR

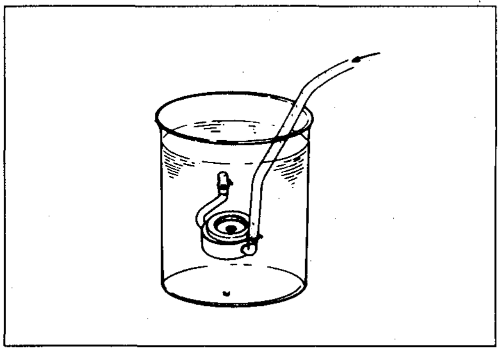
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



Relief Valve

1. Attach an oil pressure gauge to the oil gallery near the oil filter.
2. Start the engine to check the relief valve opening pressure.

Relief Valve Opening Pressure	kg/cm^2(psi/kPa)
5.8 — 6.2 (82.49 — 88.18/569.0 — 608.2)	



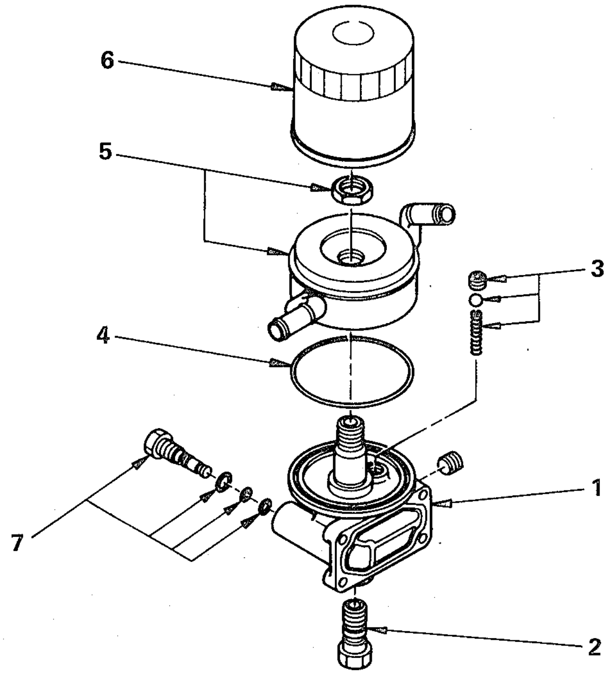
Oil Cooler

Water Leakage At Water Passage

1. Plug one side of the oil cooler water passage.
2. Submerge the oil cooler in water.
3. Apply compressed air (2 kg/cm^2 (28.45 psi/196 kPa)) to the other side of the oil cooler water passage.

   If air bubbles rise to the surface, there is water leakage.

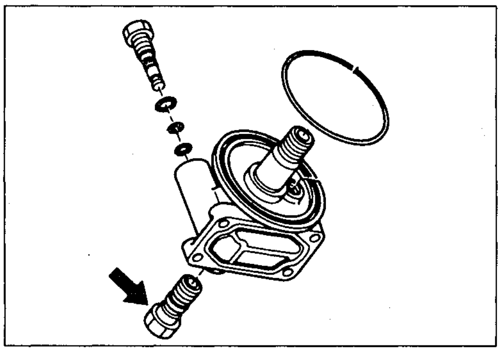
REASSEMBLY



Reassembly Steps

- 1. Oil filter body
- ▲ 2. Relief valve
- ▲ 3. Safety valve
- 4. O-ring
- ▲ 5. Oil cooler
- ▲ 6. Oil filter cartridge
- ▲ 7. Drain plug

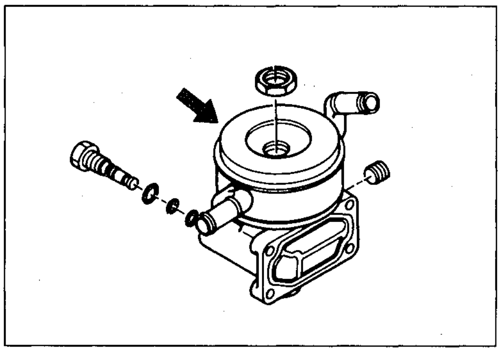
Important Operations



2. Relief Vale

Tighten the relief valve to the specified torque.

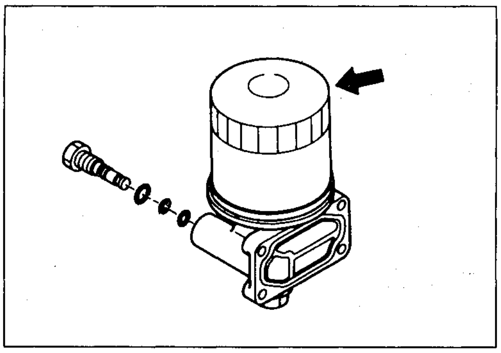
Relief Valve Torque	kg·m(lb.ft/N·m)
3.0 ± 0.5 (21.70 ± 3.62/29.4 ± 4.9)	



5. Oil Cooler

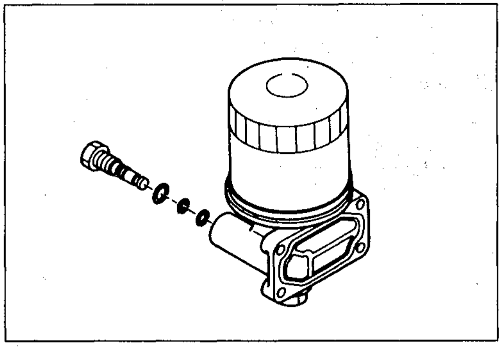
1) Align the oil filter holes with the body knock pins at installation.
2) Tighten the oil cooler to the specified torqur.

Oil Cooler Torque	kg·m(lb.ft/N·m)
3.0 ± 0.5 (21.70 ± 3.62/29.4 ± 4.9)	



6. Oil Filter Cartridge

1) Apply engine oil to the O-ring.
2) Turn in the cartridge oil filter until the filter sealing face makes contact with the O-ring.
3) Turn in the cartridge oil filter an additional 2/3 of a turn.



7. Drain Plug

Tighten the drain plug to the specified torque.

Drain Plug Torque	kg·m(lb.ft/N·m)
1.5 ± 0.5 (10.85 ± 1.45/14.7 ± 4.9)	

MEMO

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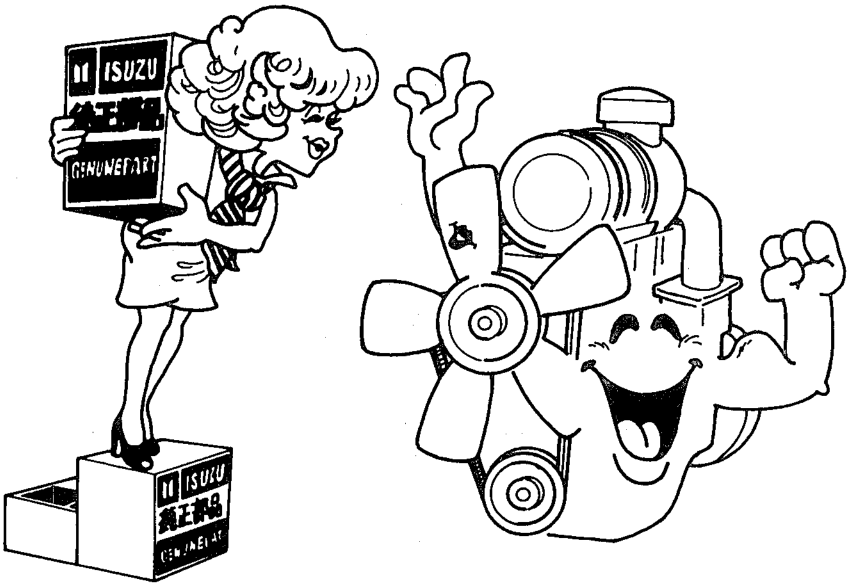
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SECTION 7

COOLING SYSTEM

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General description .... 7— 3

Water pump .... 7— 5

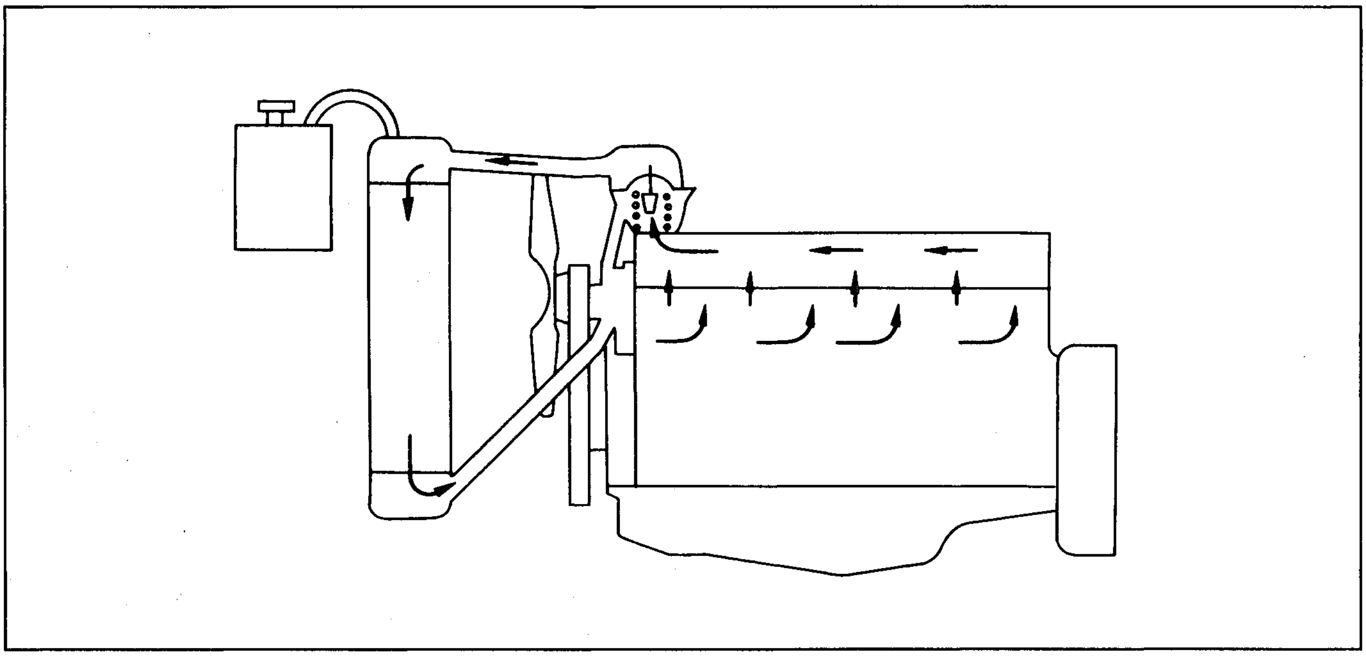
Thermostat .... 7—11

MAIN DATA AND SPECIFICATIONS

Item		
Water pump type		Centrifugal impeller
Pump to crankshaft speed ratio	(To 1)	1.1
Delivery volume	Lit(US/UK gal)/min.	100 (26.3/22.2)
Pump speed at 3000 rpm		
Water temperature at 30°C (86°F)		
Pump bearing type		Double row shaft
Thermostat type		Wax pellet with jiggle valve
Valve initial opening temperature	°C(°F)	82 (180)
Valve full opening temperature	°C(°F)	95 (203)
Valve lift at fully open position	mm(in.)	8.0 (0.31)

GENERAL DESCRIPTION

COOLANT FLOW



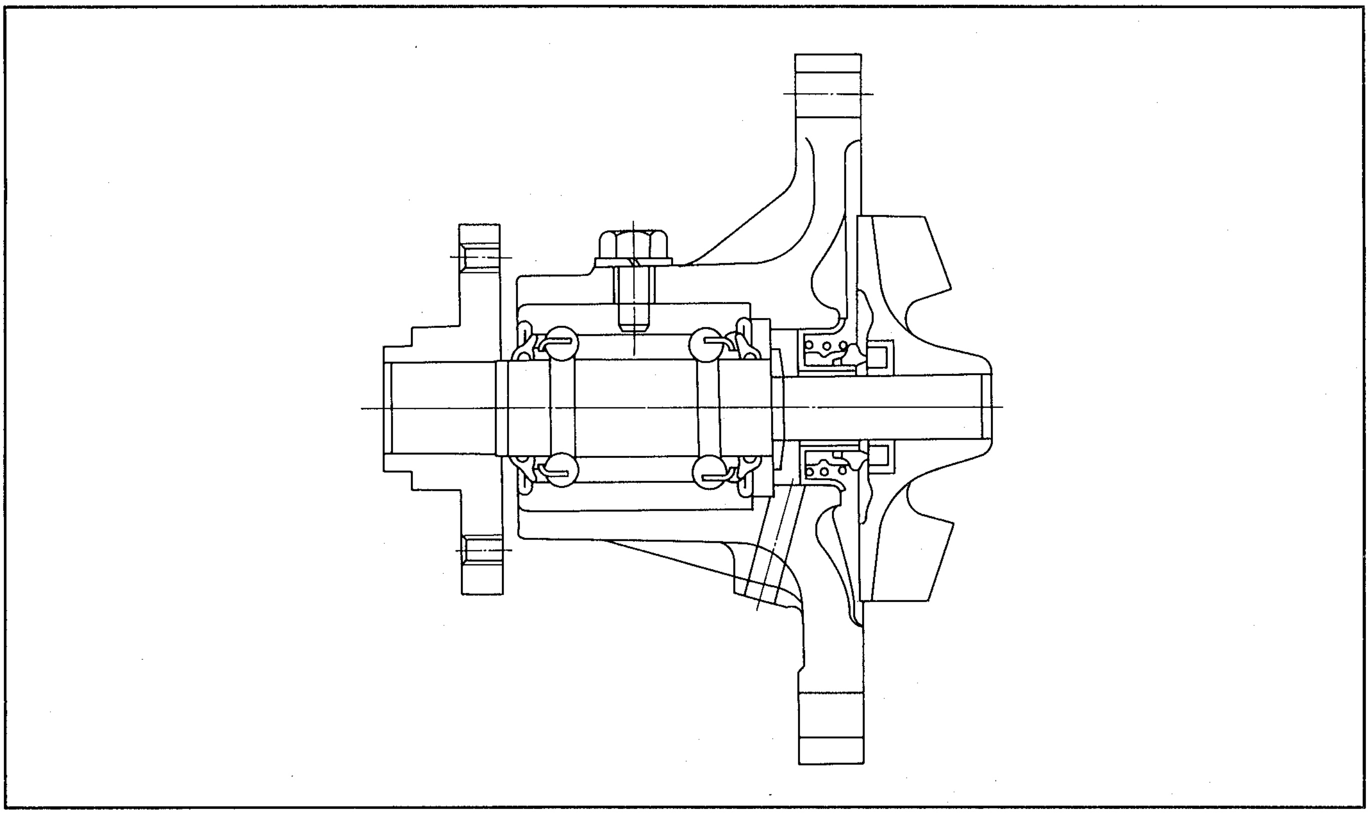
The engine cooling system consists of the radiator, the water pump, the cooling fan, and the thermostat.

To quickly increase cold engine coolant temperature for smooth engine operation, the coolant is circulated by the water pump and thermostat through the by-pass hose and back to the cylinder body. The coolant does not circulate through the radiator.

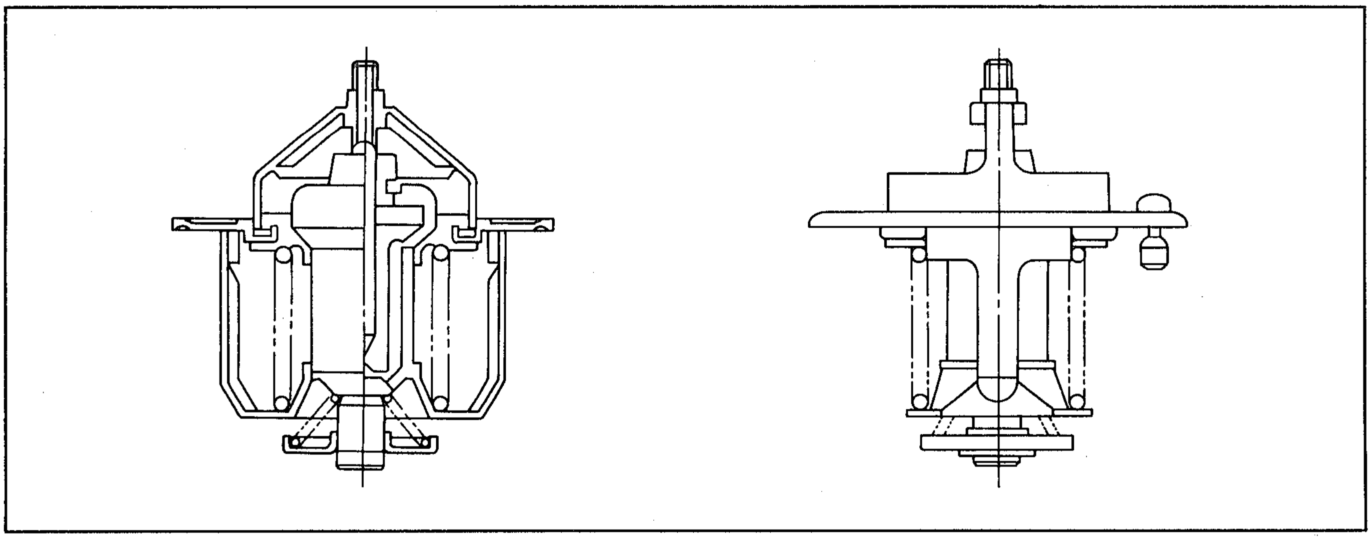
When the coolant temperature reaches 82°C (180°F), the thermostat will begin to open and a gradually increasing amount of coolant will circulate through the radiator.

The thermostat will be fully open when the coolant temperature reaches 95°C (203°F). All of the coolant is now circulating through the radiator for effective engine coolant.

WATER PUMP



THERMOSTAT



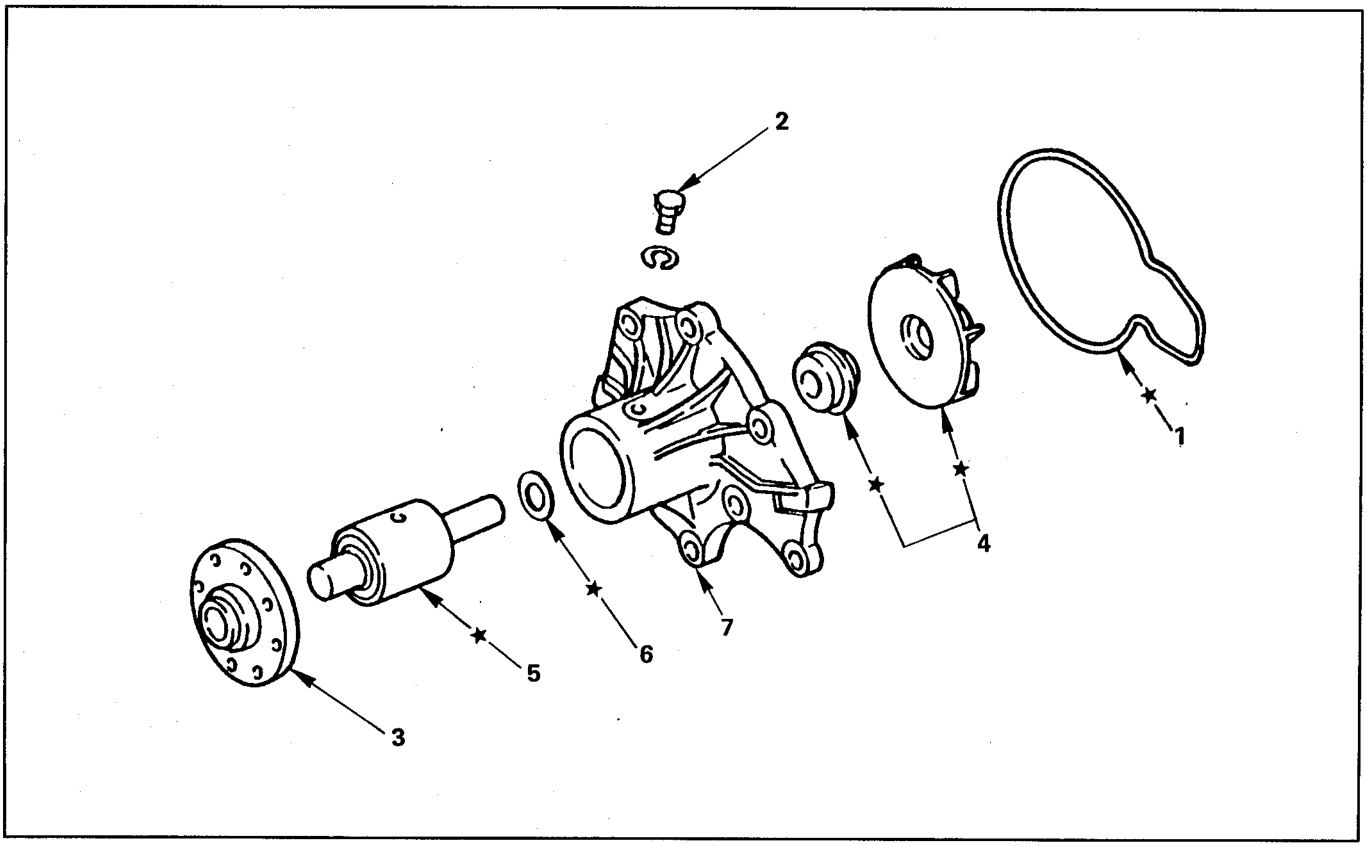
A centrifugal type water pump forcefully circulates the coolant through the cooling system.

A wax pellet type thermostat is used.

The jiggle valve accelerates engine warm-up.

WATER PUMP

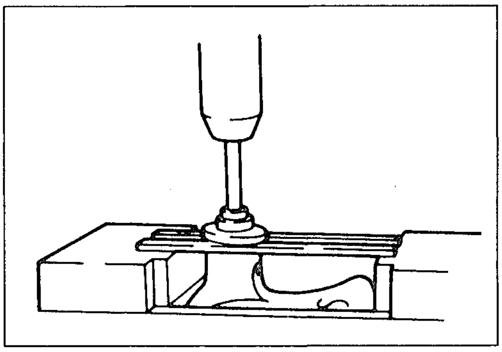
DISASSEMBLY



Disassembly Steps

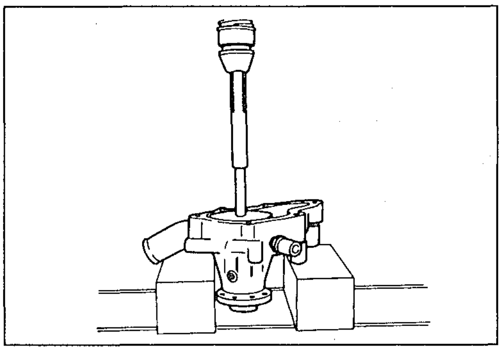
▲ 1. O-ring
2. Set screw
▲ 3. Cooling fan center
▲ 4. Impeller and seal unit
▲ 5. Bearing unit
6. Thrower
7. Water pump body

Important Operations



3. Cooling Fan Center

Remove the fan center with a bench press and a bar.



4. Impeller and Seal Unit

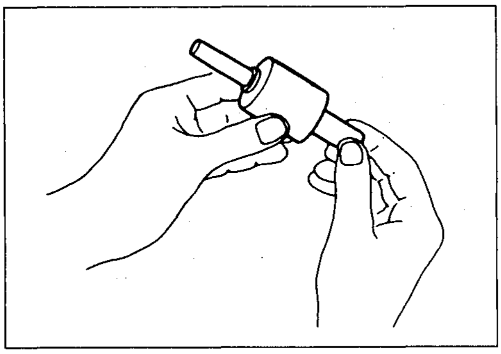
Remove the impleller and seal unit with a bench press and bar.

Note:

Do not drive out the impeller with a hammer. Damage to the impeller will result.

INSPECTION AND REPAIR

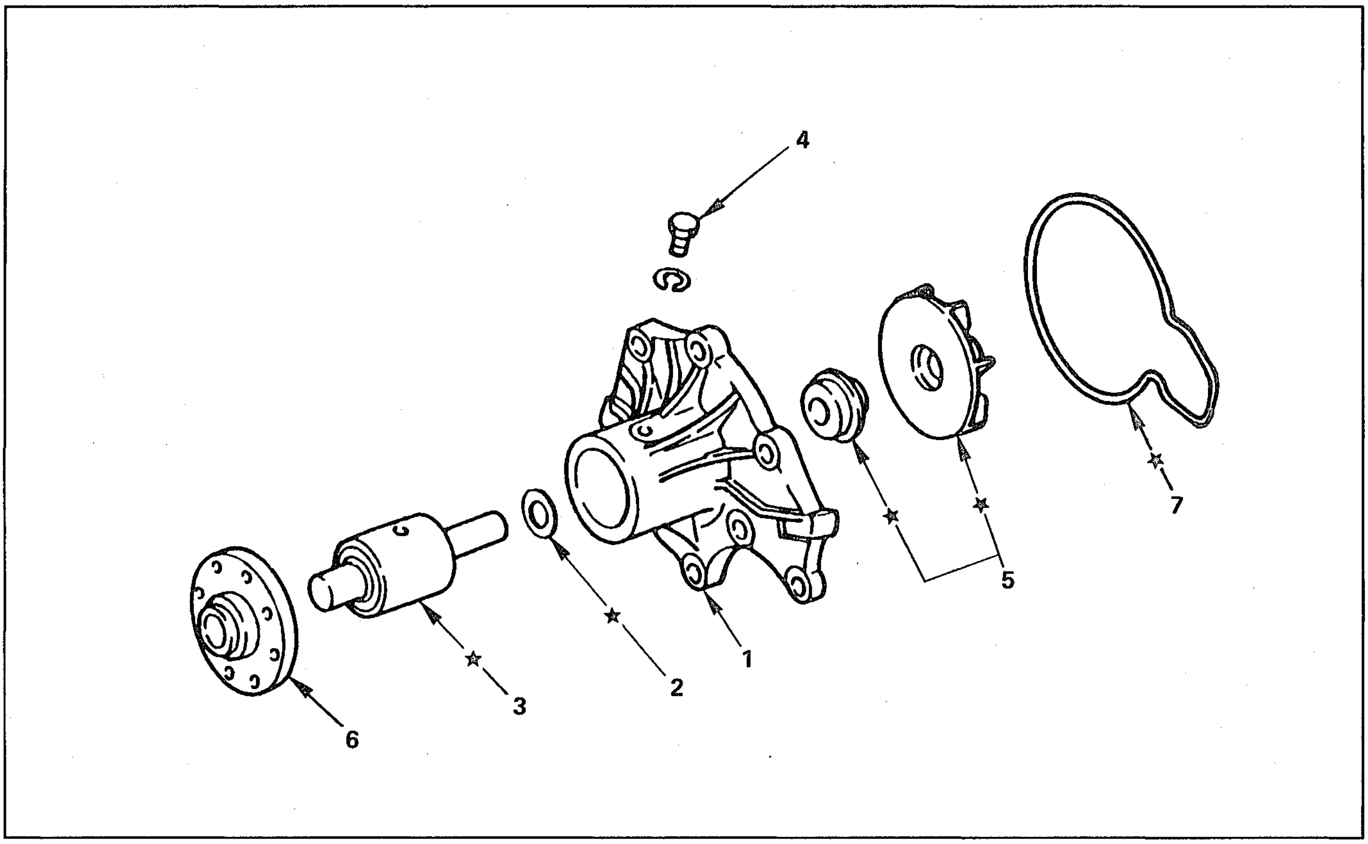
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



Bearing Unit

Check the bearing for abnormal noise, biding, and other abnormal conditions.

REASSEMBLY



Reassembly Steps

1. Water pump body
2. Thrower

▲ 3. Bearing unit

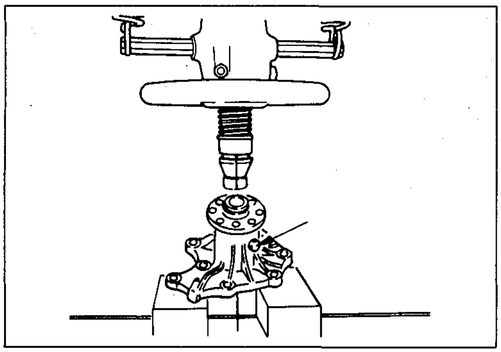
▲ 4. Set screw

▲ 5. Impeller and seal unit

▲ 6. Cooling fan center

7. O-ring

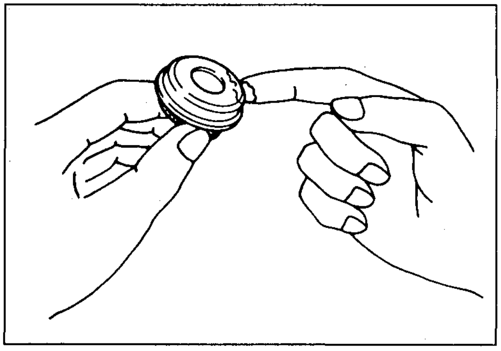
Important Operations



3. Bearing Unit

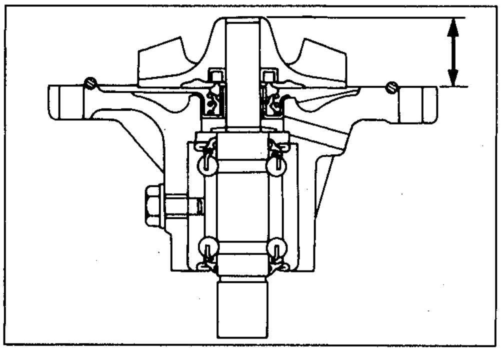
4. Set Screw

1) Align the bearing set screw hole with the pump body set screw hole.
2) Press the bearing unit into place.
3) Secure the bearing with the set screw.



5. Impeller and Seal Unit

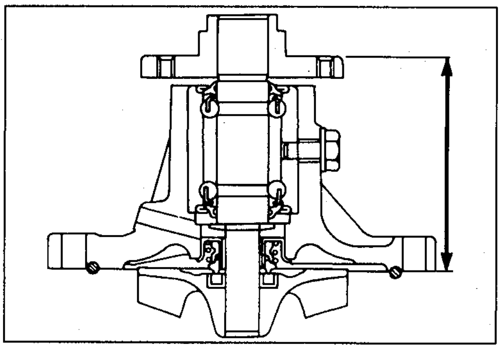
1) Apply a thin coat of liquid gasket to the seal unit outer periphery.
2) Install the seal unit.



3) Measure the impeller protection from the water pump body fitting face.

Impeller Projection mm(in.)

25.0 (0.98)

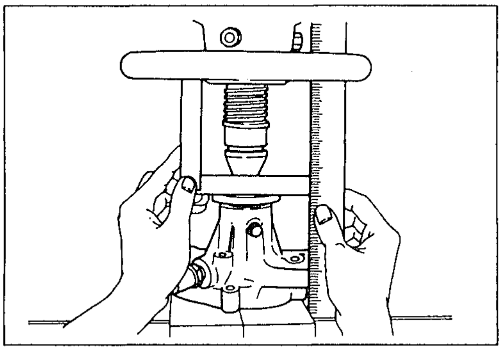


6. Cooling Fan Center

Measure the distance between the cooling fan fitting face and the water pump body fitting face.

Cooling Fan Center Distance mm(in.)

79.2 — 79.8 (3.12 — 3.14)



Note:

1. The fan center and the impeller are installed to the water pump shaft with a press.

   Never attempt to remove and reinstall the fan center and the impeller a second time. Replace the entire water pump assembly.

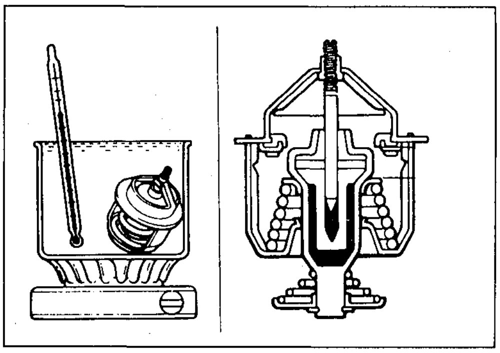
   Removing and reinstalling the fan cente and the impeller a second time may result in the breakdown of the water pump during engine operation and subsequent serious overheating problems.

2. The water pump assembly must be replaced whenever the fan center and impeller pressure force falls below 200 kg.
3. Do not attempt to strike the bearing into position with a hammer or similar object. Damage to the bearing will rusult.

THERMOSTAT

INSPECTION AND REPAIR

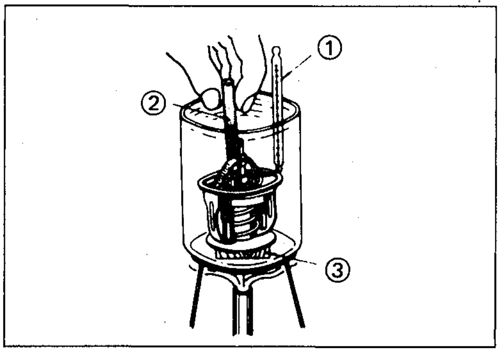
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



Operating Test

1. Completely submerge the thermostat in water.
2. Heat the water.

   Stir the water constantly to avoid direct heat being applied to the thermostat.



3. Check the thermostat initial opening temperature.

Thermostat Initial Opening Temperature	°C(°F)
82 (182)	

4. Check the thermostat full opening temperature.

Thermostat Full Opening Temperature	°C(°F)
95 (203)	

Valve Lift at Fully Open Position	mm(in.)
8.0 (0.31)	

① Thermostat
② Agitating Rod
③ Wooden Piece

MEMO

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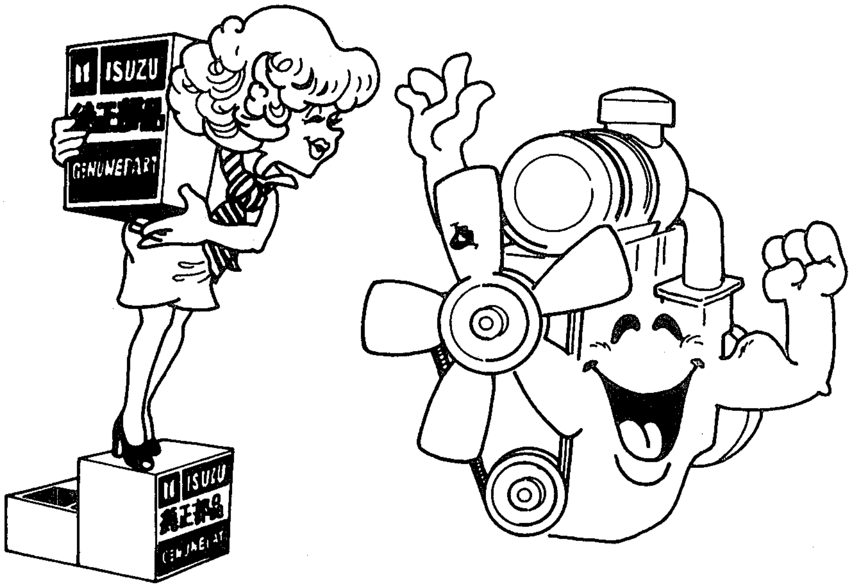
ISUZU
純正部品
GENUINE PART
ISUZU
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GENUINE PART

SECTION 8

FUEL SYSTEM

TABLE OF CONTENTS

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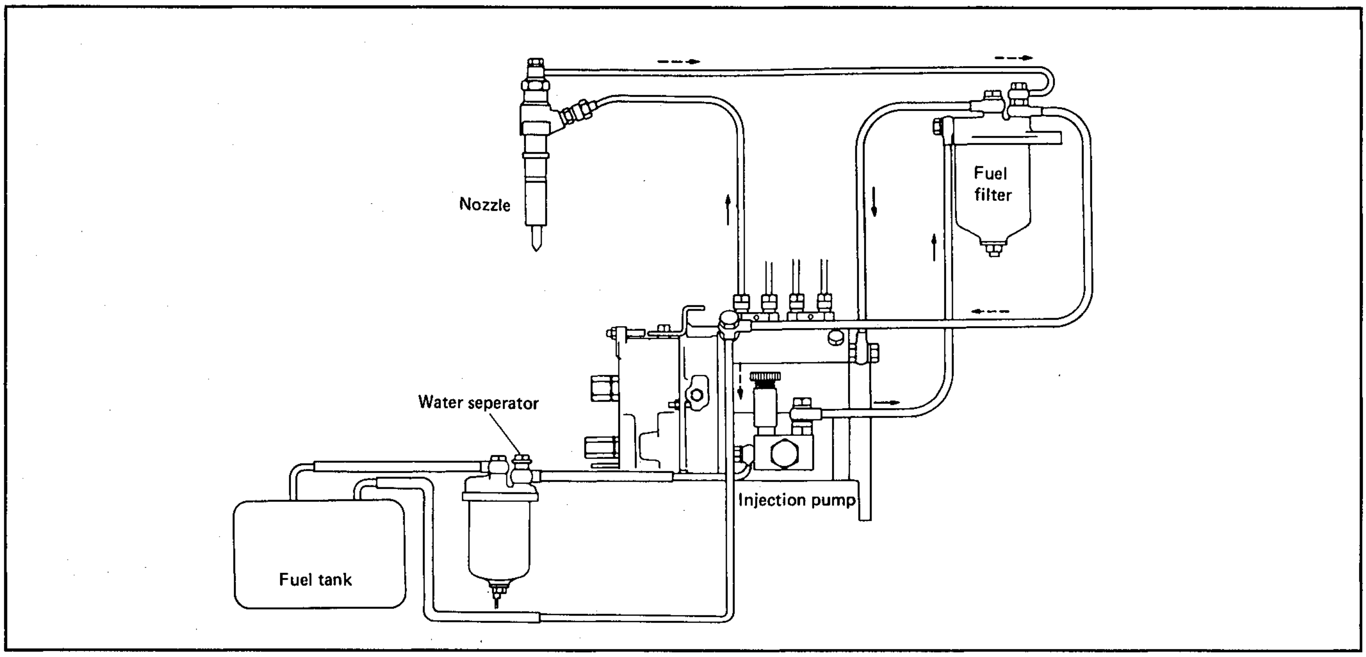
Main data and specifications .... 8— 2
General description .... 8— 3
Injection nozzle .... 8— 6
Injection pump data .... 8—11

MAIN DATA AND SPECIFICATIONS

Item		
Injection pump type		Bosch A type
Plunger outside diameter	mm(in.)	9.0 (0.35)
Plunger lift	mm(in.)	3.25 – 3.35 (0.128 – 0.132)
Governor type		RSV variable speed mechanical type
Fuel feed pump type		Single action
Injection nozzle type		Hole type
Number of injection nozzle orifices		4
Injection nozzle orifice inside diameter	mm(in.)	1.0 (0.039)
Injection nozzle opening pressure	kg/cm^2(psi/kPa)	185 (2,630/18,142)
Main fuel filter type		Cartridge paper element water separator Water separator (if so equipped)

GENERAL DESCRIPTION

COOLANT FLOW

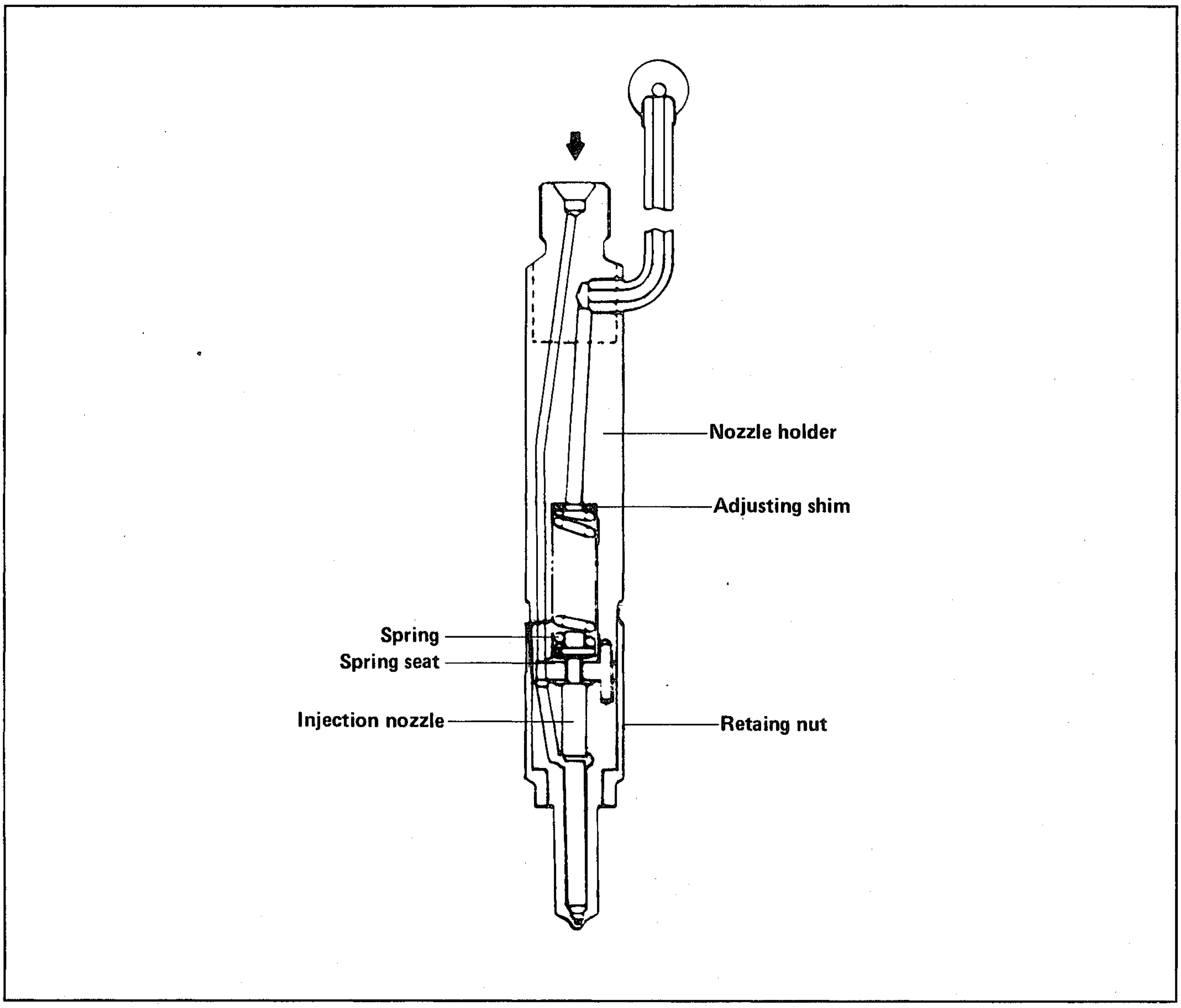

Nozzle
Fuel filter
Water seperator
Injection pump
Fuel tank

The fuel system consists of the fuel tank, the water separator (if so equipped), the fuel filter, the injection pump, and the injection nozzle.

The fuel from the fuel tank passes through the water separator and the fuel filter where water particles and other foreign material are removed from the fuel.

Fuel, fed by the injection pump plunger, is delivered to the injection nozzle in the measured volume at the optimum timing for efficient engine operation.

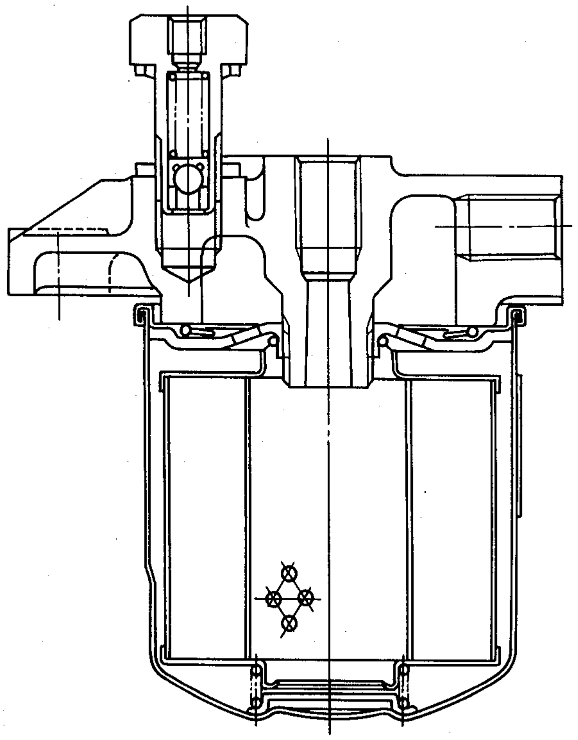
INJECTION NOZZLE

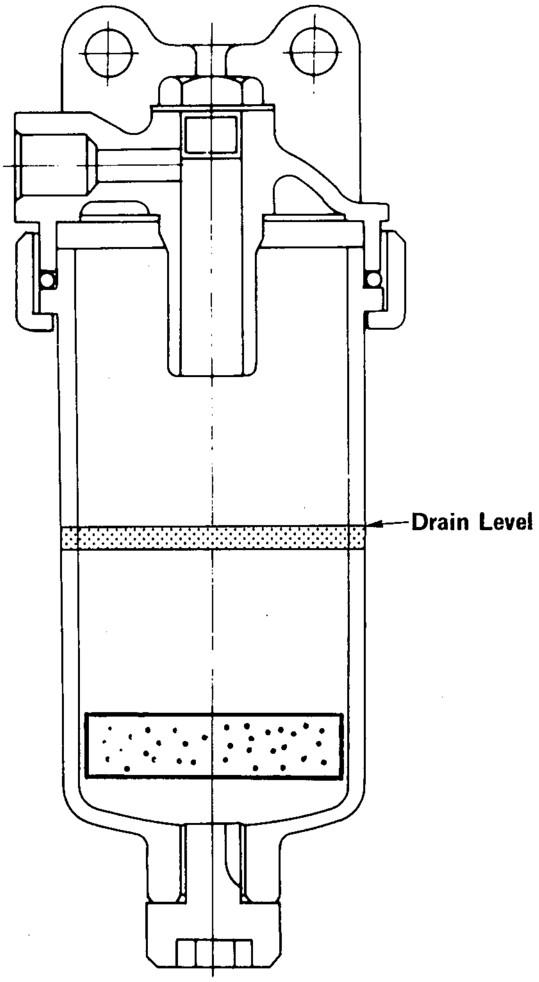

Nozzle holder
Adjusting shim
Spring
Spring seat
Injection nozzle
Retaing nut

A hole (with 4 orifices) type injection nozzle is used. It consists of the nozzle body and the needle valve assembly.

The injection nozzle sprays pressurized fuel from the injection pump into the combustion chamber through the nozzle body injection orifice.

FUEL FILTER AND WATER SEPARATOR





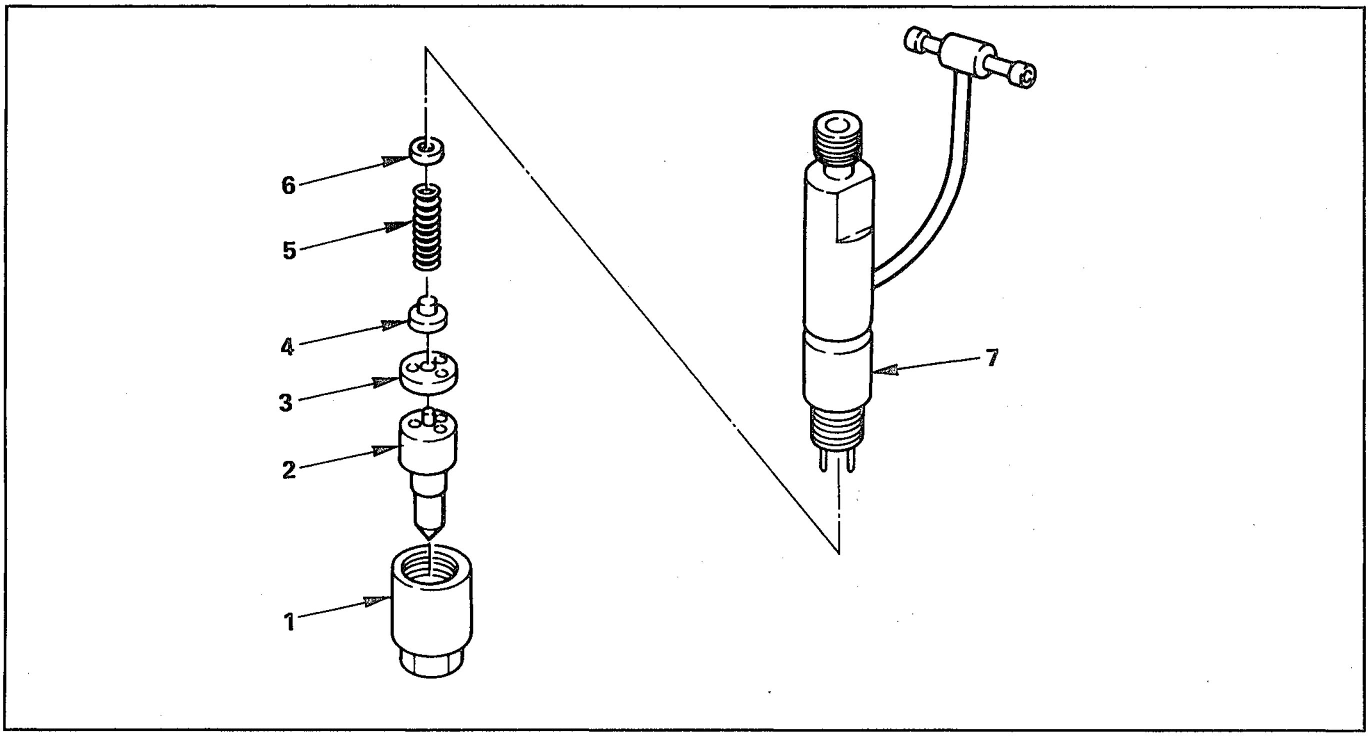
A cartridge type fuel filter and a water separator are used.

As the inside of the injection pump is lubricated by the fuel which it is pumping, the fuel must be perfectly clean. The fuel filter and the water separator remove water particles and other foreign material from the fuel before it reaches the injection pump.

The water separator has an internal float. When the float reaches the drain level, remind you to drain the water from the water separator.

INJECTION NOZZLE

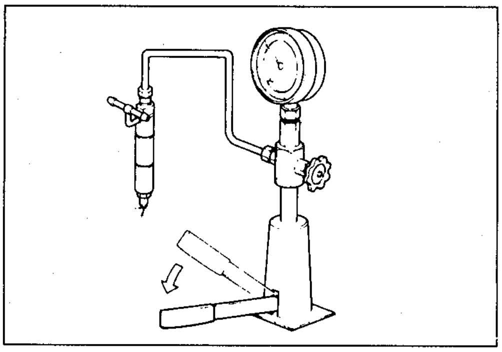
DISASSEMBLY



Disassembly Steps

1. Retaining nut
▲ 2. Injection nozzle
3. Spacer
4. Spring seat
5. Spring
6. Adjusting shim
7. Nozzle holder

Important Operations



Performance this test before disassembling the injection nozzle.

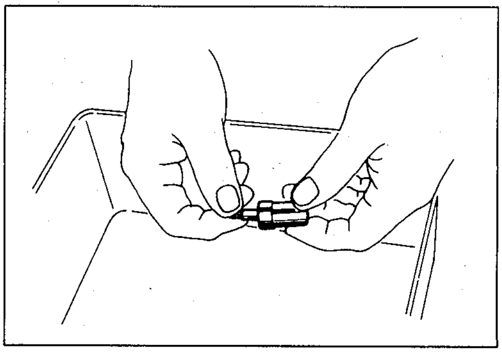
1) Install the injection nozzle to the nozzle tester.
2) Use the nozzle tester to apply compressed fuel at 185 kg/cm^2 (2,631 psi) to the injection nozzle.
3) Check the area around the nozzle seat for fuel leakage.

   If there is fuel leakage, the injection nozzle and the injection body must be replaced as a set.

2. Injection Nozzle

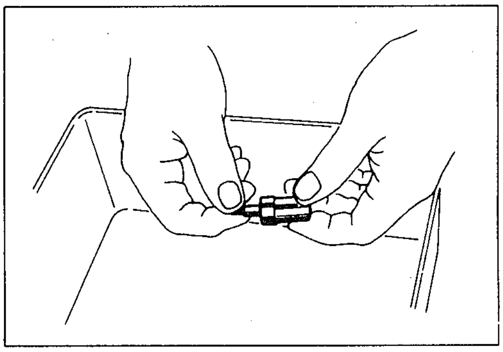
1) Remove the injection nozzles from the nozzle holders.

   The nozzle needle valve and nozzle body combinations must be interchange.
2) Immerse the injection nozzles in a tool tray filled with clean diesel fuel to protect them from dust.



INSPECTION AND REPAIR

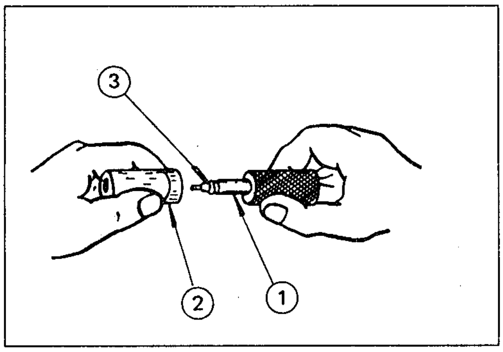
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



Injection Nozzle Needle Inspection

1. Remove the nozzle needle from the nozzle body.
2. Carefully wash the nozzle needle and the nozzle body in clean diesel fuel.
3. Check that the nozzle needle moves smoothly inside the injection nozzle body.

   If the nozzle needle does not moves smoothly, it must be repaired (See "Nozzle Lapping Procedure" below.)



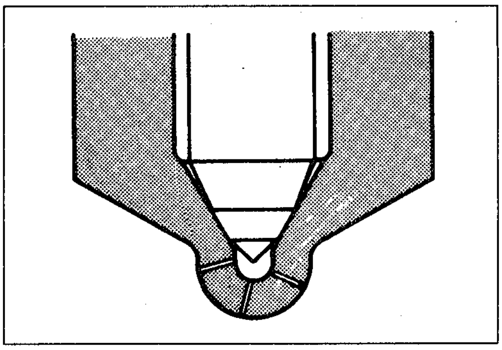
Nozzle Lapping Procedure

1. Lap the nozzle needle ① and the nozzle body ② by applying a compound of oxidized chrome and animal oil ③.

Note:

Do not apply an excessive amount of the oxidized chrome and animal oil compound to the injection needle valve seat area.

2. Carefully wash the needle valve and the nozzle body in clean diesel fuel after lapping.

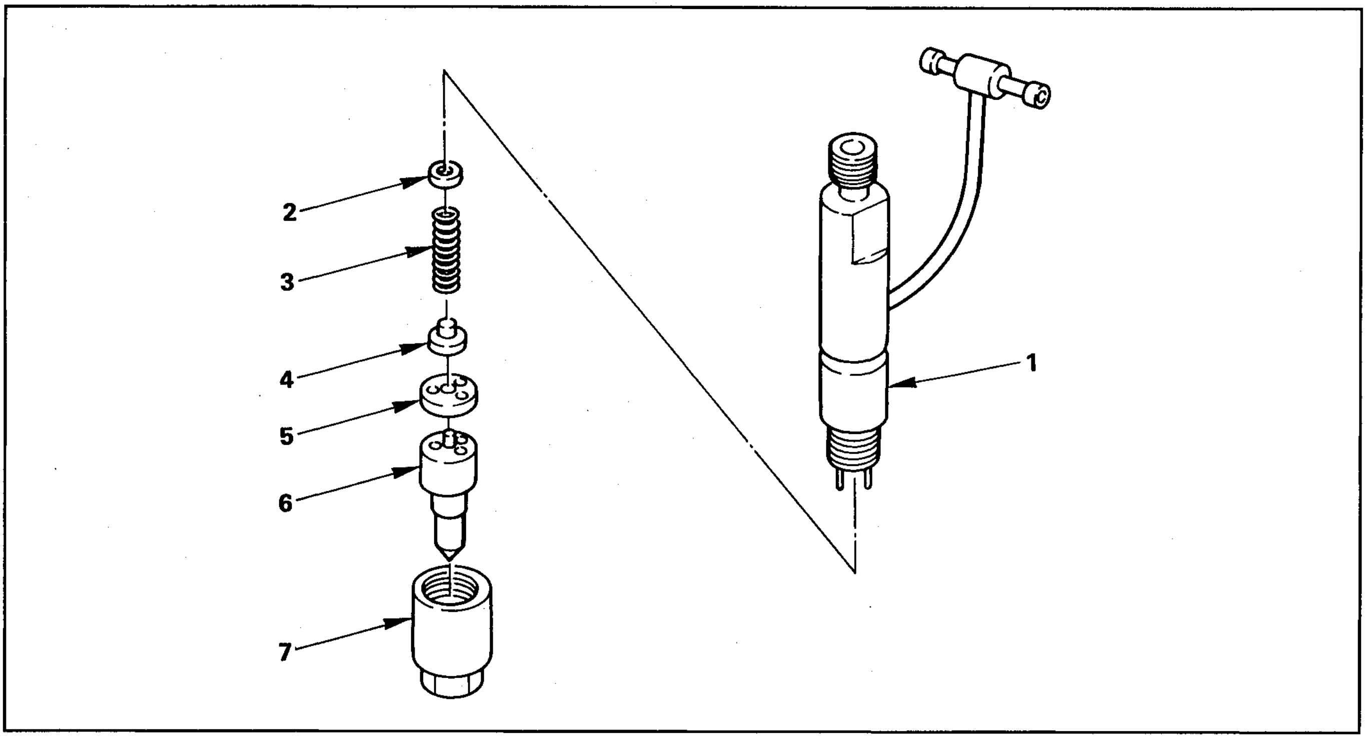


Nozzle Body and Needle Valve Inspection

Check the nozzle body and the needle valve for damage and deformation.

The nozzle and body must be replaced if either of these two conditions are discovered during inspection.

REASSEMBLY



Reassembly Steps

1. Nozzle holder
- ▲ 2. Adjusting shim
3. Spring
4. Spring seat
5. Spacer
6. Injection nozzle
- ▲ 7. Retaining nut

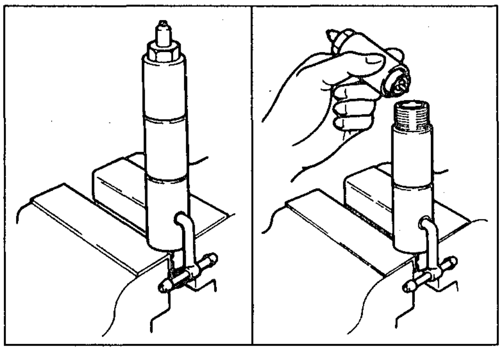
Important Operations

2. Adjust Shim

Adjust Shim Availability mm(in.)

Range	0.50—0.50 (0.02—0.06)
Increment	0.025 (0.001)

Total No. of Shims 40

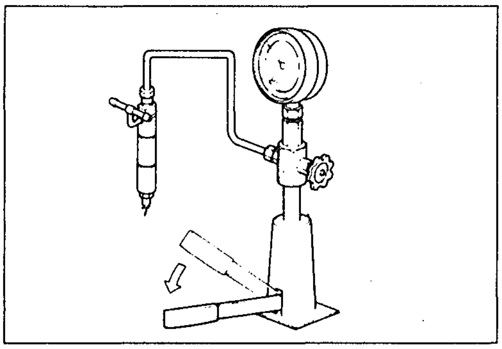


7. Retaining Nut

Tighten to the retaining nut to the specified torque.

Retaining Nut Torque kg·m(lbs.ft./N·m)

4.5 ± 0.5 (32.5 ± 3.6/44.0 ± 4.9)



Injection Nozzle Adjustment

1. Attach the injection nozzle holder to the injection nozzle tester.
2. Apply pressure to the nozzle tester to check that the injection nozzle opens at the specified pressure.

   If the injection nozzle does not open at hte specified pressure, install or remove the appropriate number of adjusting shims to adjust it.

(Reference)

Removing or installing one shim will increase or decrease the nozzle opening pressure approximately 3.77 kg/cm^2 (53.6 psi).

WARNING:

TEST FLUID FROM THE INJECTION NOZZLE TESTER WILL SPRAY OUT UNDER GREAT PRESSURE. IT CAN EASILY PUNCTURE A PERSON'S SKIN. KEEP YOUR HANDS AWAY FROM THE INJECTION NOZZLE TESTER AT ALL TIMES.

INJECTION PUMP DATA

INJECTION PUMP IDENTIFICATION

Refer to the Item "INJECTION PUMP IDENTIFICATION" on Page 1— of the "SERVICING" Section of this Workshop Manual.

INJECTION VOLUME ADJUSTMENT

TEST CONDITIONS

Injection Nozzle		* DKKC No.: 105780-0000 Bosch Type No.: DN12DS12T
Injection Nozzle Holder		DKKC No.: 105780-2080 Bosch Type No.: EF8511/9A
Injection Starting Pressure	kg/cm²(psi/kPa)	175.0 (2488.5/17168.0)
Injection Line Dimensions	mm(in.)	
Inside Diameter		2.0 (0.079)
Outside Diameter		6.0 (0.236)
Length		600.0 (23.6)
Transfer Pump Pressure		1.6 (22.75)
Testing Diesel Fuel		ISO4113 or SAE Standard Test Oil (SAEJ967D)
Operating Temperature	°C(°F)	40 - 45 (104 - 113)
Pump Rotation Direction		Clockwise (Viewed from the drive side)

* DKKC ..... Diesel Kiki Co., Ltd.

INJECTION QUANTITY

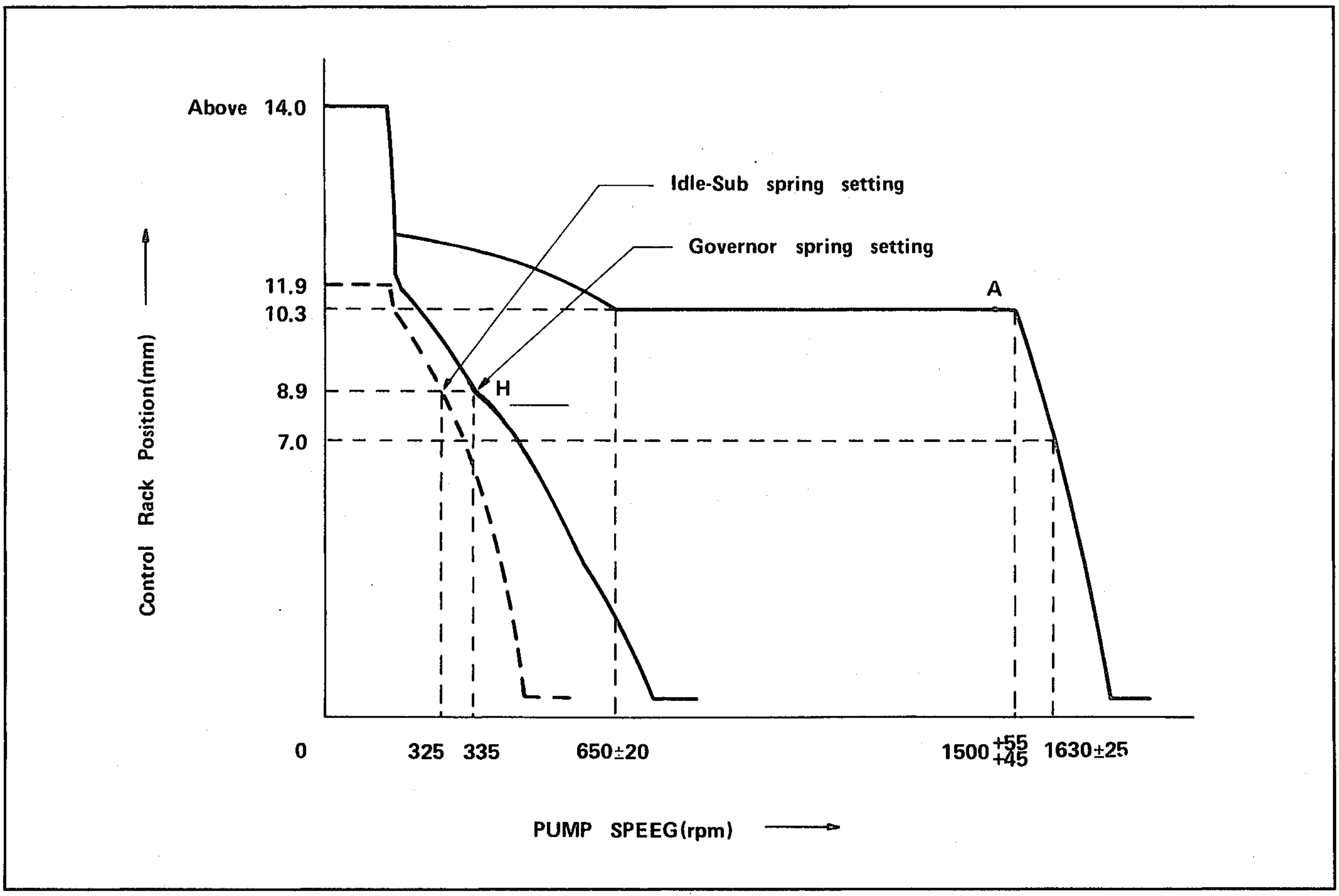
Adjusting Point	Rod Position (mm)	Pump Speed (rpm)	Injection Quantity (cc/1,000 Strokes)	Maximum Variation (%)	Fixed	Remarks
A	10.3	1,500	37.2 – 39.2	± 2.5	Rod	Basic
H	About 5.6	335	7.4 – 11.4	± 15.0	Rod	Basic
A	About 9.6	1,100	37.2 – 39.2	± 15.0	Lever	Basic

Pre-Stroke: No. 1 Plunger 3.3 ± 0.05 mm
Injection Order: 1-3-2-4 (Plunger numbered from the governor side)
Tappet Clearance: More than 0.3 mm for all cylinders

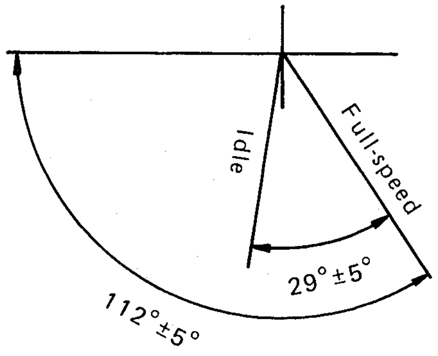
* This performance drawing for 4JC1 PC only.

GOVERNOR ADJUSTMENT

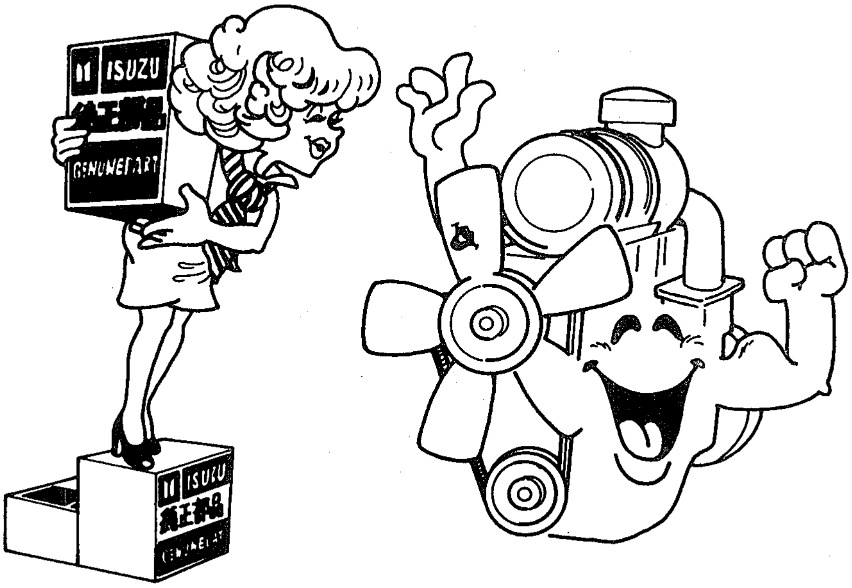
Full Adjustment



Speed Lever Angle


Idle
Full-speed
29° ±5°
112° ±5°

MEMO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SECTION 9

ENGINE ELECTRICALS

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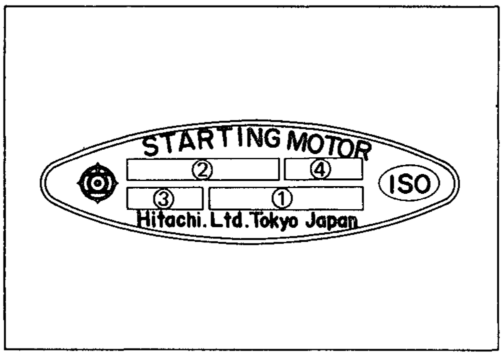
Alternator .... 9—15

STARTER MOTOR



STARTER MOTOR IDENTIFICATION

Hitachi starter motors are identified by name plate attached to the yoke. (Illustration)

① Isuzu part number
② Manufacturer's code number
③ Rated output
④ Manufacturer's production mark

Note:

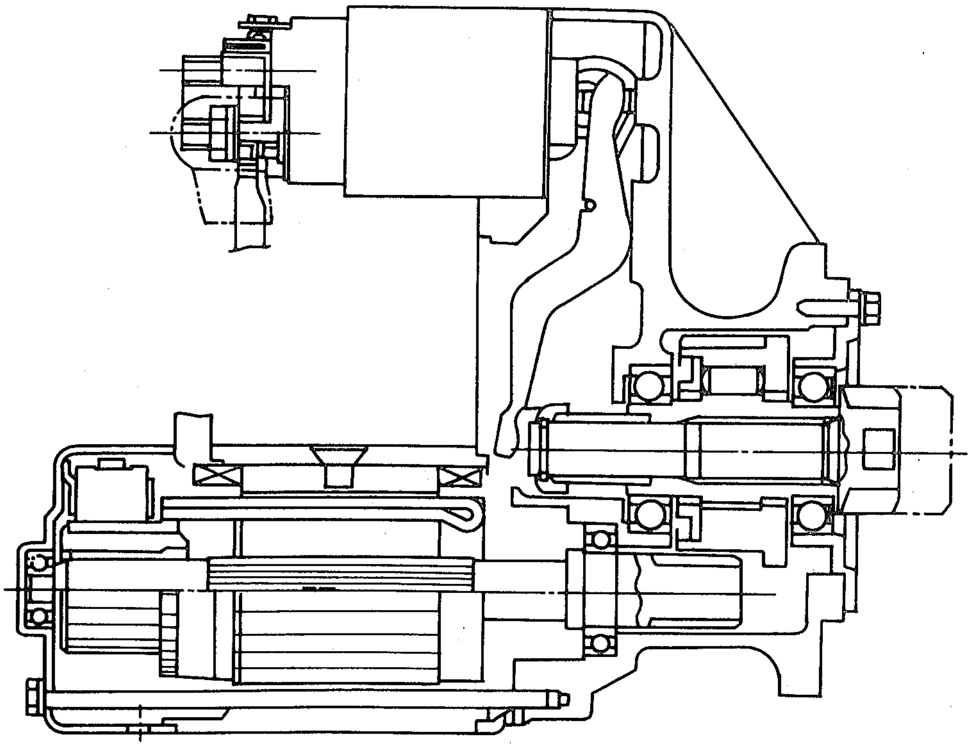
Always check the identification number before beginning a service operation.

Applicable service data will vary according to the identification number. Use of the wrong service data will result in startor motor damage.

MAIN DATA AND SPECIFICATION

Isuzu Part No.		8-94410-409-0	8-94423-452-0
Hitachi code No.		S13-11	S24-07
Rated voltage	V	12	24
Rated output	mm(kW)	2.2	3.5
Rating	mm(Sec)		
Direction of rotation			
(Viewed from the pinion side)		Clockwise	
Clutch type		Roller	
Terminal voltage (No. Load)	V	11	23
Minimum current (No. Load)	A	160	90
Starter motor minimum operating speed			
(No. Load)	rpm	3900	3100
Pinion gear			
Modules		2.75	
Number of teeth		9	
Outside diameter	mm(in.)	33.0 (4.3)	
Travel distance	mm(in.)	1.51 (0.059)	
Yoke outside diameter	mm(in.)	80.0 (3.15)	
Number of poles		4	
Magnetic switch (at 20°C [68°F])			
Series coil resitance	Ω	—	
Shut coil resistance	Ω	0.27	1.25
Brush length			
Standard	mm(in.)	15.0 (0.59)	15.0 (0.59)
Limit	mm(in.)	9.0 (0.35)	9.0 (0.35)
Brush spring standard fitting load	kg(lb./N)	(3.52/15.7—4.4/19.6)	(2.5/24.5—7.7/34.3)
Commutator			
Outside diameter			
Standard	mm(in.)	30.0 (1.18)	36.5 (1.44)
Limit	mm(in.)	29.0 (1.14)	35.5 (1.40)
Difference between the largest and smallest diameters			
Standard	mm(in.)	0.05 (0.002)	
Depth of undercut mica			
Limit	mm(in.)	0.10 (0.004)	
Standard	mm(in.)	0.5 — 0.8 (0.02 — 0.03)	
Limit	mm(in.)	0.2 (0.008)	

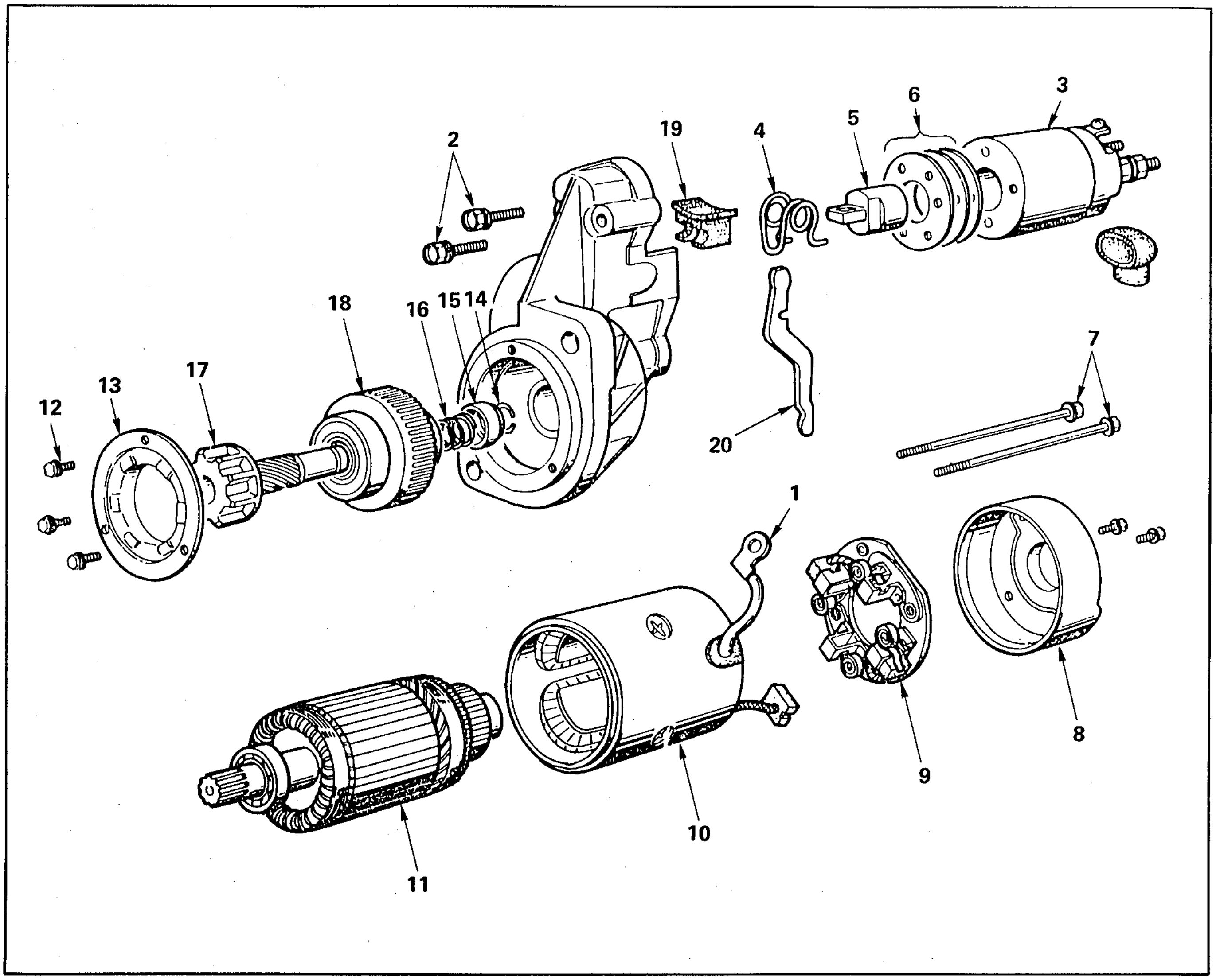
GENERAL DESCRIPTION



This startor motor is equipped with a reduction gear between the armature shaft and the flywheel ring gear drive pinion.

This construction enable the startor motor to reduce 27% of the armature shaft revolution speed at the pinion contributing to achieve more compact size and higher cold engine starting ability than the non-reduction gear type starter motor.

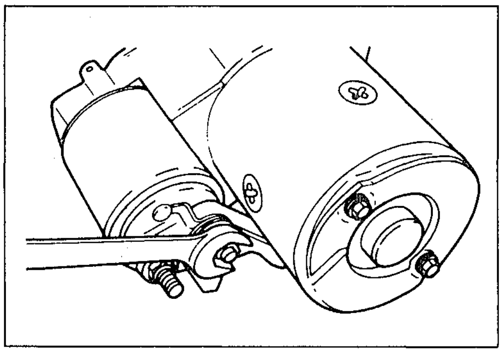
DISASSEMBLY


2
19
4
5
6
3
18
16
15
14
13
17
12
7
20
1
8
9
10
11

Disassembly Steps

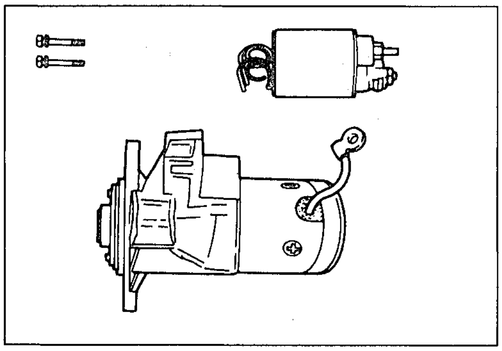
▲ 1. Lead wire	11. Armature
2. Bolt	12. Screw
▲ 3. Magnetic switch	▲ 13. Bearing retainer
▲ 4. Torsion spring	▲ 14. Snap ring
▲ 5. Plunger	15. Pinion stopper
▲ 6. Shim	16. Return spring
▲ 7. Through bolt	17. Pinion shaft
8. Rear cover	18. Overrunning clutch
9. Brush holder	19. Dust cover
10. Yoke	20. Shift lever

Important Operations



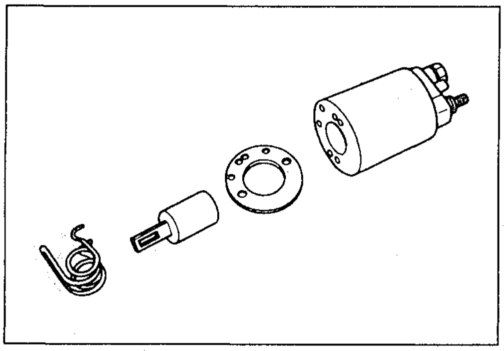
1. **Lead Wire**

   Disconnect lead wire at the magnetic switch.



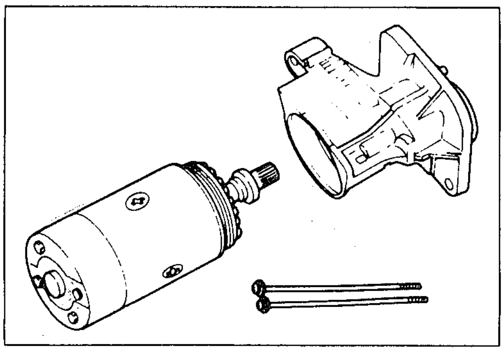
3. **Magnetic Switch**

   Remove the magnetic switch fixing bolts, then remove the switch from the shift lever.



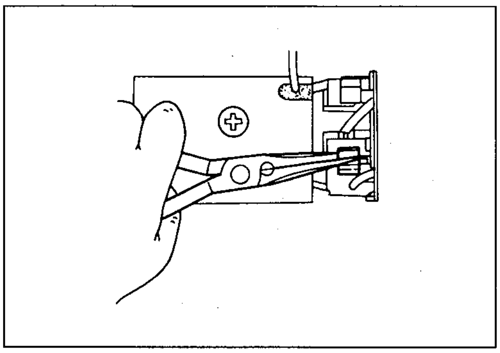
4. **Torsion Spring**
5. **Plunger**
6. **Shim**

   Remove the torsion spring, plunger and shim from the magnetic switch.



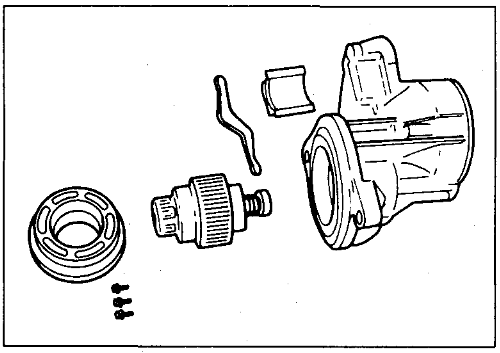
7. **Through bolt**

   Remove the yoke, armature and brush holder together from the gear case.



9. Brush Holder

Using long-nose pliers remove the 4 brushes.



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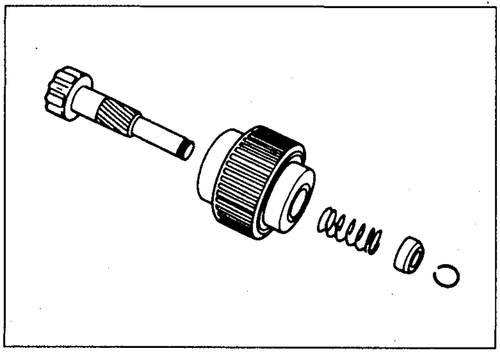
13. Bearing retainer

Remove the bearing retainer, then remove the pinion from the gear case.



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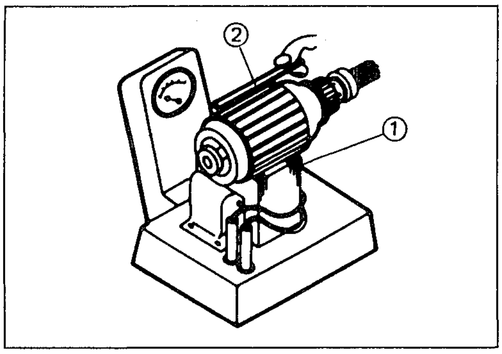
14. Snap Ring

Remove the snap ring using a screw driver or equivalent, then disassemble the pinion assembly.

INSPECTION AND REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



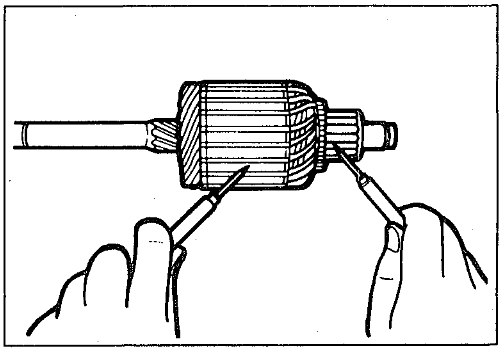
ARMATURE

Armature Short Circuit Test

1. Place the armature on a growler tester ①.
2. Hold a hack saw blade ② against the armature core while slowly rotating the armature.

   If the armature is short circuited, the hack saw blade will vibrate and will be attracted to the armature core.

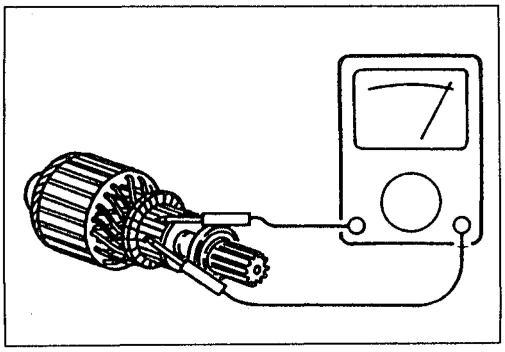
   A short circuited armature must be replaced.



Armature Winding Ground Test

Check for continuity across the commutator segments and the core.

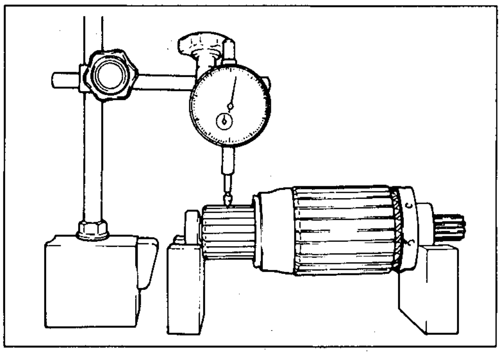
If there is continuity, the armature is internally grounded due to insulation failure and must be replaced.



Armature Winding Continuity Test

Check for continuity across the commutator segment.

If there is no continuity, the armature coil is open and must be replaced.



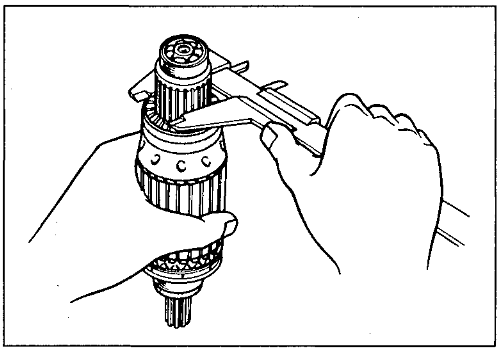
Commutator Run-Out Test

Use a dial indicator and a V-block to measure the commutator runout.

If the measure value exceeds the limit, the commutator must be replaced.

Commutator Run-Out mm(in.)

Standard	Limit
0.02 (0.0008)	0.05 (0.002)



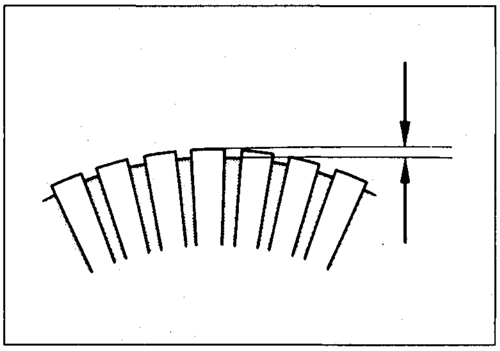
Commutator Outside Diameter Measurement

Use a vernier caliper to measure the commutator outside diameter.

If the measured value exceeds the limit, the armature must be replaced.

Commutator Outside Diameter mm(in.)

	Standard	Limit
S13 — 11	30.0 (1.18)	29.0 (1.14)
S24 — 07	36.5 (1.44)	35.5 (1.40)



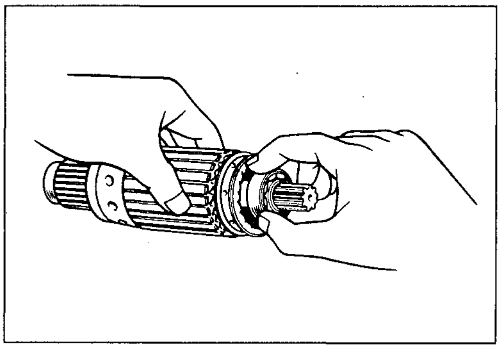
Segment Mica Depth Measurement

Use a depth gauge to measure the segment mica depth.

If the measured value exceeds the limit, the segment mica must be undercut.

Segment Mica Depth mm(in.)

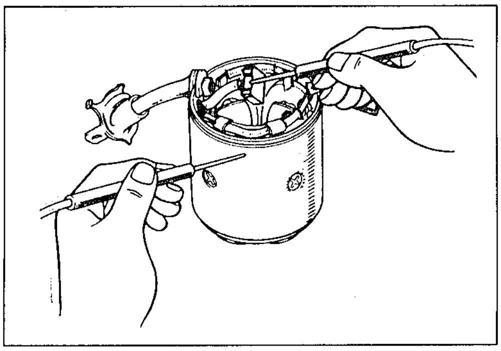
Standard	Limit
0.5 — 0.8 (0.02 — 0.03)	0.2 (0.008)



Bearing Inspection

Visually inspect the bearing.

If the bearing is worn or damaged, it must be replaced.



YOKE

Field Winding Ground Test

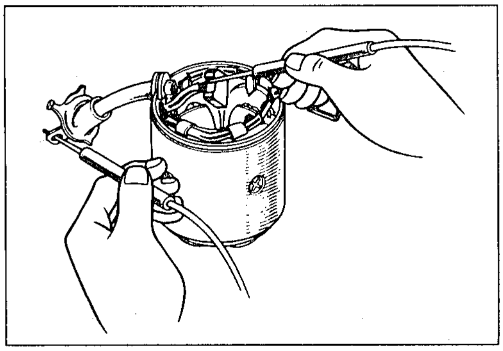
Use a circuit tester to check the field winding ground.

1. Touch one probe to the brush field winding end.
2. Touch the other probe to the bare surface of the yoke body.

   There should be no continuity.

   If there is continuity, the field windings are gounded.

   Repair or replace the field windings.



Field Winding Continuity Test

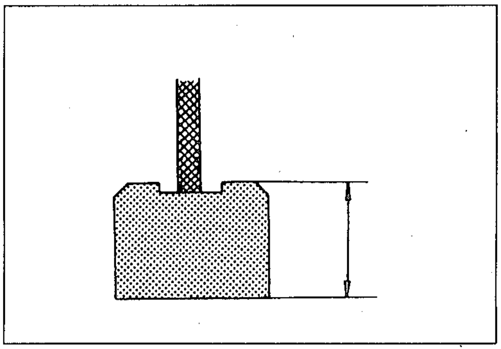
Use a circuit tester to check the field winding continuity.

1. Touch one probe to the field winding lead wire.
2. Touch the other probe to the brush.

   There should be continuity.

   If there is no continuity, the field windings are open.

   Repair or replace the field windings.



BRUSH AND BRUSH HOLDER

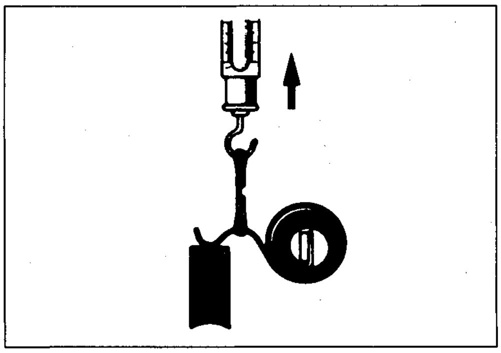
Brush Length Measurement

Use a vernier caliper to measure the brush length.

If the measured value exceeds the limit, the brush and/ or the yoke must be replaced.

Brush Length mm(in.)

Standard	Limit
20.0 (0.79)	13.0 (0.51)



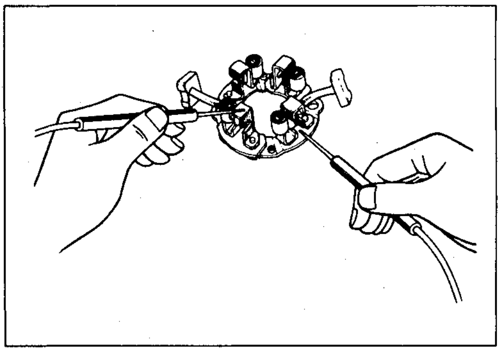
Brush Spring Inspection

Visually check the brush spring for weakness and rusting.

Replace the brush spring if it is weak or rusted.

Use a spring balancer to measure the spring tension.

If the measured valve exceeds the limit, the brush spring must be replaced.



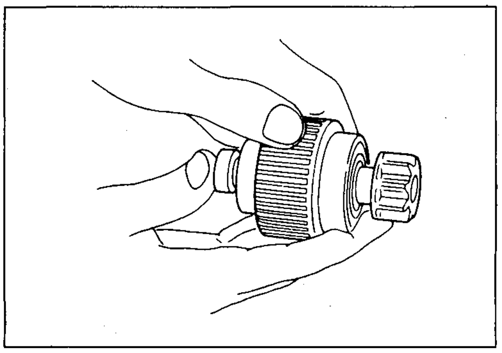
Brush Holder Insulation Test

Use a circuit tester to check the brush holder insulation.

1. Touch one probe to the field winding lead wire.
2. Touch the other probe to the brush.

   There should be no continuity.

   If there is continuity, the brush holder must be repaired or replaced.

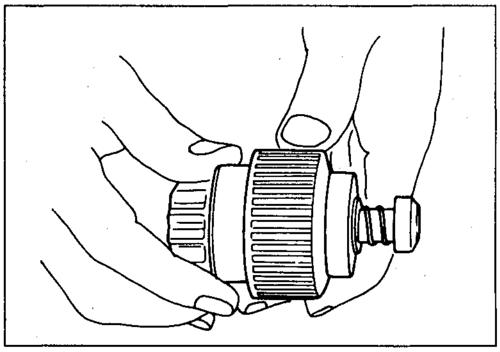


PINION CLUTCH

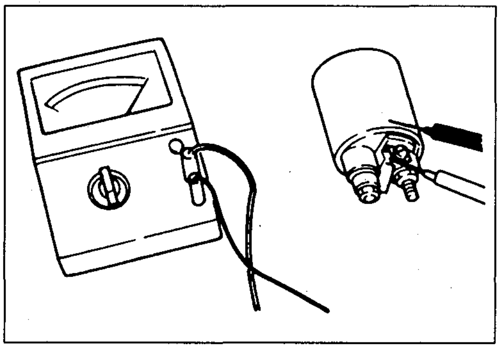
Pinion Inspection

Use your hand to turn the pinion in the direction of starter motor rotation. The pinion should turn freely.

Try to turn the pinion in the opposite direction. The pinion should lock.

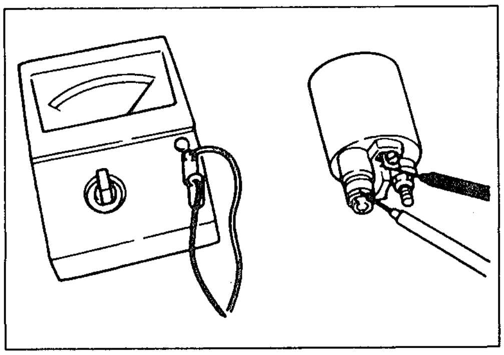


Check the bearing for binding or play by spinning the ball bearing by holding the outer race with fingers.



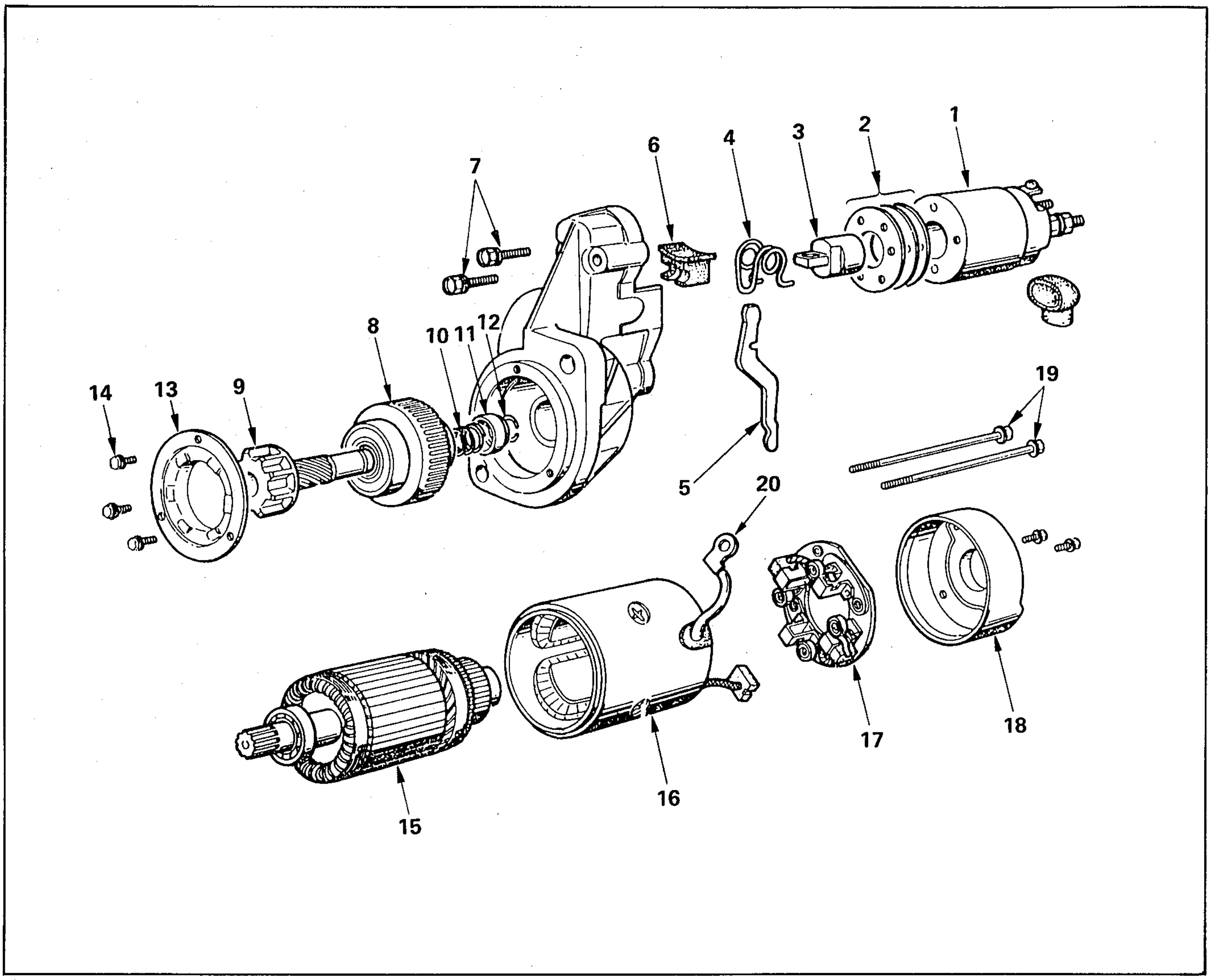
MAGNETIC SWITCH

Check for continuity across the magnetic switch "S" terminal and coil case. If no continuity exists, the shunt coil is open and should be replaced.



Check for continuity across magnetic switch "S" terminal and "M" terminal. If no continuity exists, series coil are open and should be replaced.

REASSEMBLY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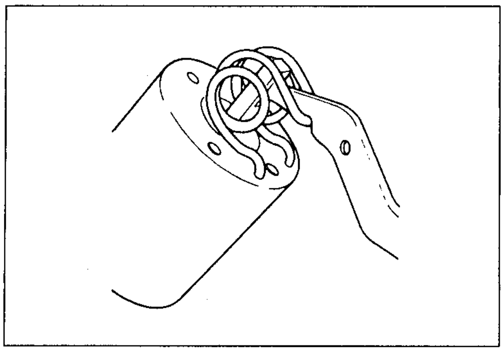
Reassembly Steps

	1. Magnetic switch		11. Pinion stopper
	2. Shim		12. Snap ring
	3. Plunger		13. Bearing retainer
▲	4. Torsion spring		14. Bolt
▲	5. Shift lever		15. Armature
▲	6. Dust cover		16. Yoke
	7. Bolt	▲	17. Brush holder
	8. Overrunning clutch		18. Rear cover
▲	9. Pinion	▲	19. Through bolt
	10. Return spring	▲	20. Lead wire

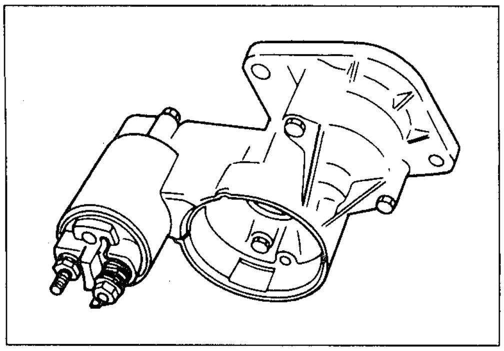
Important Operations



4. Torsion Spring

5. Shift Lever

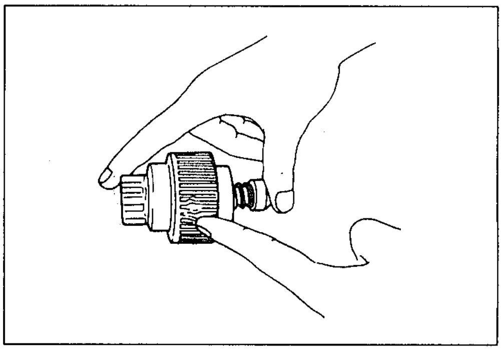
Set the torsion spring to the hole in magnetic switch.
Insert the shift lever, via the torsion spring, into plunger hole in the magnetic switch.



6. Dust cover

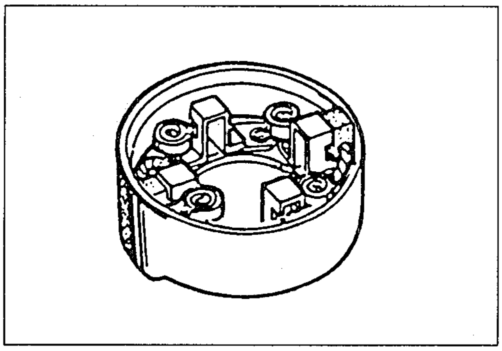
Install the magnetic switch in gear case.
Make sure to install the dust cover.

Dust Cover Bolt Torque	kg·m(lb.ft./N·m)
0.75 ± 0.5 (5.4 ± 3.6/7.4 ± 4.9)	



9. Pinion

Install the pinion after applying grease to the reduction gear.

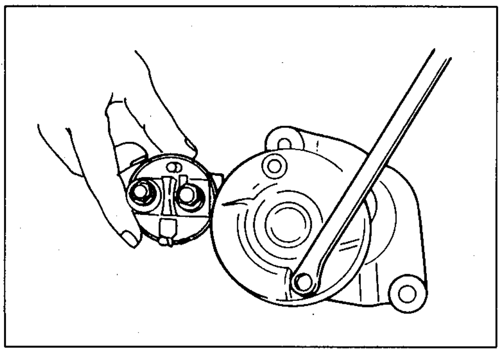


17. Brush Holders

When installing brushes, exercise care so as not to cause dmage to the commutator face.

Install the brush by raising the end of the brush spring.

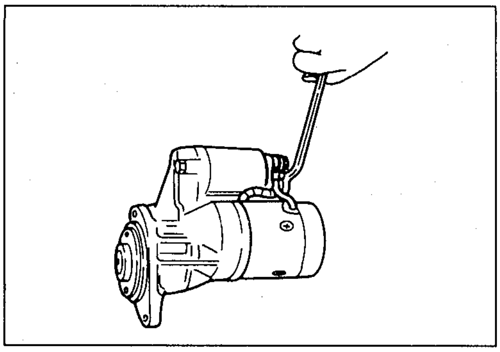
Install the brush holder by aligning it with the yoke.



19. Through Bolt

Tighten the through bolts to the specified torque a little at a time.

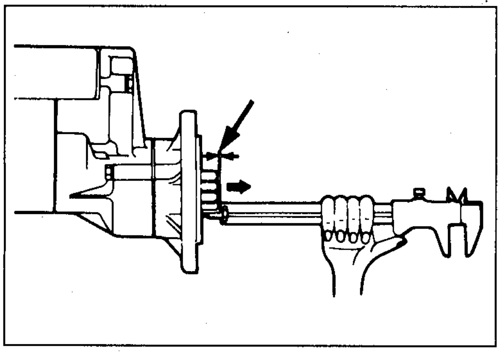
Through Bolt Torque	kg·m(lb.ft./N·m)
0.6 ± 0.1 (4.3 ± 0.7/5.9 ± 1.0)	



20. Lead Wire

Tighten the lead wire to the specified torque.

Lead Wire Torque	kg·m(lb.ft./N·m)
0.9 ± 0.1 (6.5 ± 0.7/8.8 ± 1.0)	

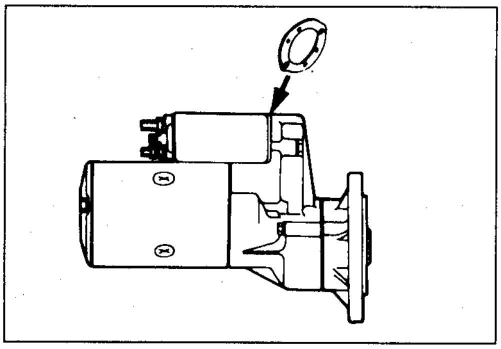


Inspection After Reassembly

The pinion jumps out as the magnetic switch "S" terminals is connected to the battery positive terminal and negative terminal is connected to the gear case.
Check the difference between the point to which the pinion is jumped out and point to which pinion can be pulled out (in direction of arrow) with fingers.

Pinion Gap	mm(in.)
0.3 – 1.5 (0.012 – 0.060)	

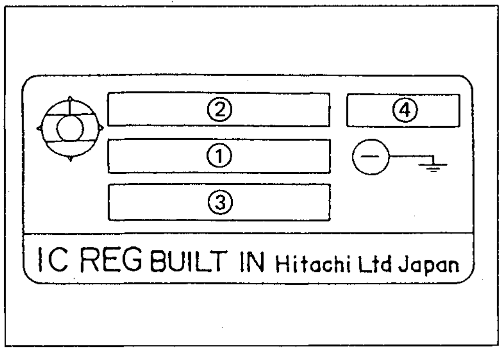
When checking the pinion gap avoid keeping magnetic switch engaged for more than 30 seconds.



When Pinion Gap Deviates From Specified Value

Make and adjustment using a shim.
Adjusting shims are available in thicknesses of 0.5 mm (0.02 in.) and 0.8 mm (0.03 in.)

ALTERNATOR



ALTERNATOR IDENTIFICATION

Hitachi alternators are identified by name plater attached to the rear cover. (Illustration)

1 Isuzu part number
2 Manufacturer's code number
3 Rated output
4 Manufacturer's production mark

Note:

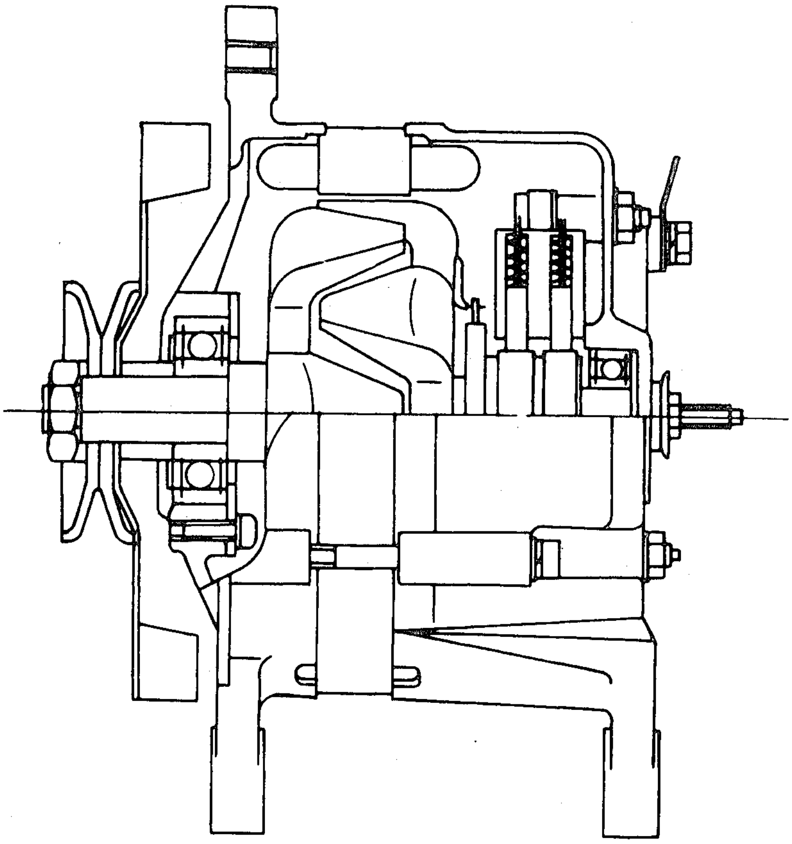
Always check the identification number before beginning a service operation.

Applicable service data will vary according to the identification number. Use of the wrong service data will result alternator damaged.

MAIN DATA AND SPECIFICATION

Engine Model to be Equipped		4J Series		
Manufacturer's name		HITACHI		
Isuzu Part No.		8-94423-756-0	8-94431-560-0	5-81200-335-0
Manufacturer's Code No.		LR135-127	LR215-50	LR200-24
Rated voltage	V	12	24	24
Rated output	A	35	15	20
Operating speed	rpm	1000—13500	1000—5000	1000—13500
Rated output at rpm	A/V/rpm	33-37/13.5/5000	15/27/5000	20/27/5000
No-load output at 0 amperes	V/rpm	13.5/1000 or less	27/1000 or less	27/1000 or less
Direction of rotation (viewed from the pulley side)		Clockwise		
Polarity grounded		Negative		
Pulley diameter (P.C.D.)	mm(in.)	80 (3.15)		
Coil resistance at 20°C				
Rotor coil	Ω	3.11	18.2	12.72
Startor coil	Ω	0.13	0.199	0.402
Brush length				
Standard	mm(in.)	14.5 (0.57)	16.0 (0.63)	14.5 (0.57)
Limit	mm(in.)	7.5 (0.30)	7.0 (0.28)	7.5 (0.30)
Slipring diameter:				
Standard	mm(in.)	31.6 (1.24)		
Limit	mm(in.)	30.6 (1.20)		
Shaft diameter				
Front	mm(in.)	15.0 (0.59)	17.0 (0.70)	15.0 (0.59)
Rear	mm(in.)	12.0 (0.47)	12.0 (0.47)	12.0 (0.47)
Regulator(s) applicable			Built-in	
Isuzu Parts No.		5-81270-004-0	5-81251-016-0	5-81251-016-0
manufacturer(s) code No.		TR1Z-63	TR2Z-47	TR2Z-47

GENERAL DESCRIPTION

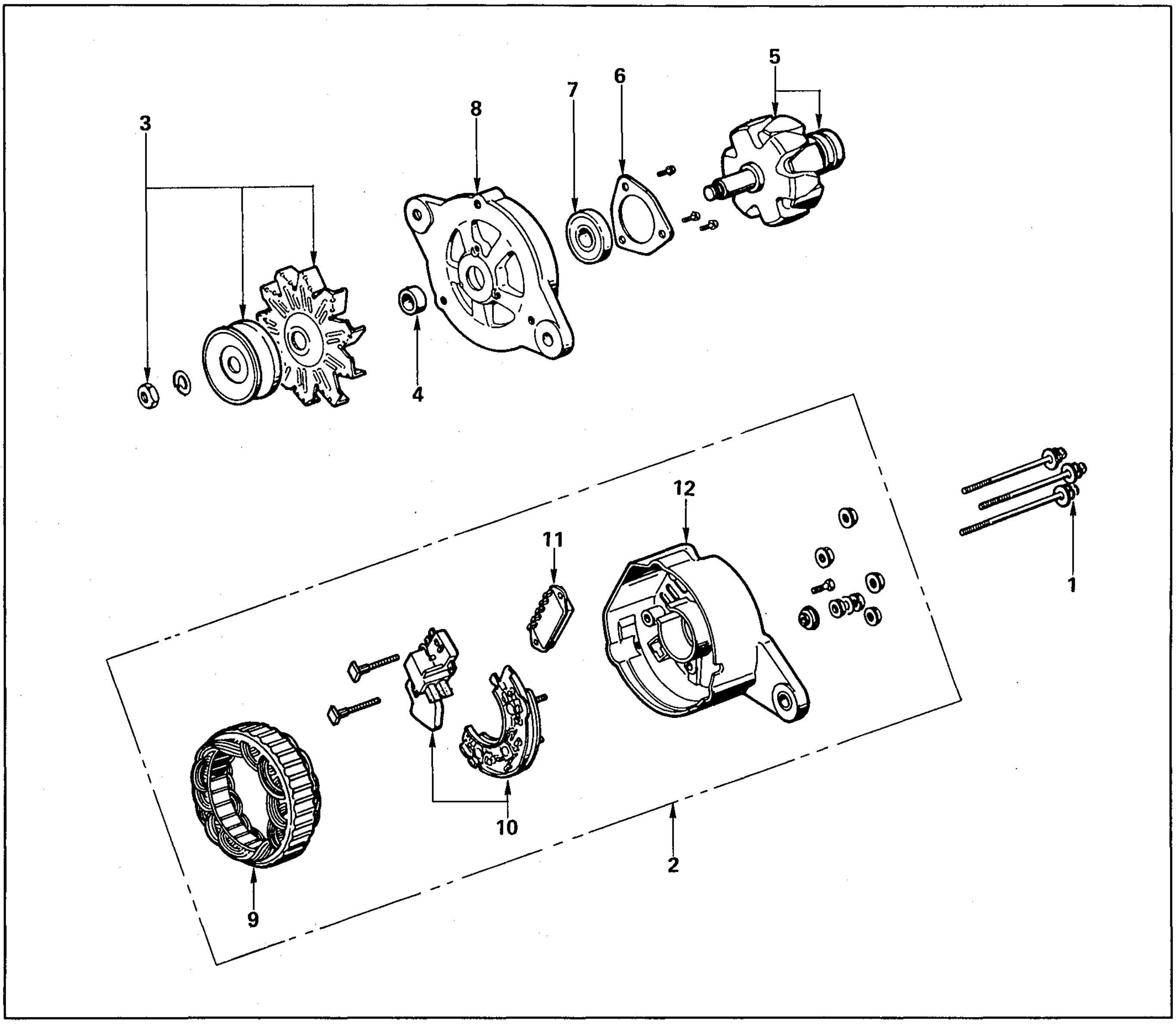


The alternator consists of the front cover, the rotor, the stator, the built-in IC regulator (some engines use a Tirrell alternator with separate regulator), and the rear cover.

This small size and light weight alternator provides excellent reliability. Its simple construction makes it very easy to service. The built-in IC regulator minimizes circut wiring.

DISASSEMBLY

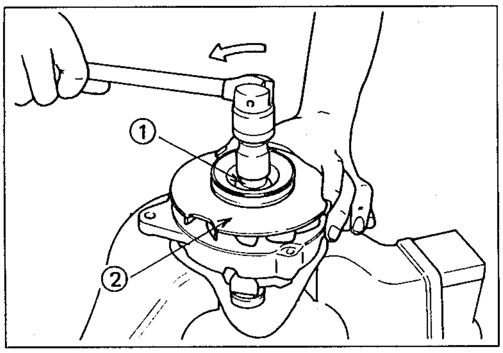
These disassembly steps are based on the built-in IC regulator type.



Disassembly Steps

1. Through bolt	7. Ball bearing
2. Rear cover and stator	8. Front cover
▲ 3. Pulley and fan	▲ 9. Stator
▲ 4. Spacer collar	▲ 10. Rectifier with brush holder
5. Rotor with bearing	11. IC regulator
6. Bearing retainer	12. Rear cover

Important Operations

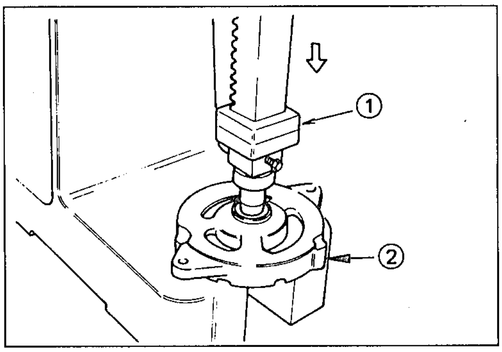


3. Pully and Fan

(1) Clamp the rotor shaft in a soft jaw vise.

(2) Loosen the pulley lock nut ①.

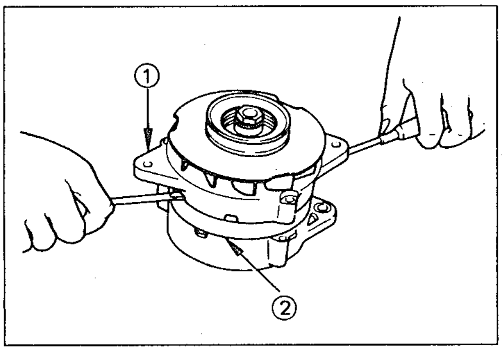
(3) Remove the pulley ② along with the spacer collar.



4. Rotor and Bearing

(1) Use a plastic hammer or a press ① to remove the rotor from the front cover ②.

(2) Remove the spacer collar.

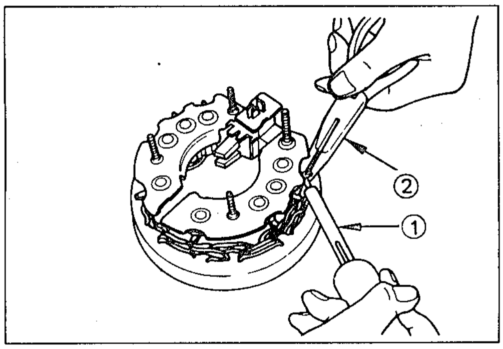


8. Front Cover

Use screwdrivers to pry the front cover ① from the stator ②.

Note:

Do not attempt to pry the coil wires from the stator.



9. Stator

10. Rectifier with Brush Holder

Use a soldering iron ① and a pair of long nose pliers ② to remove the rectifiers.

Note:

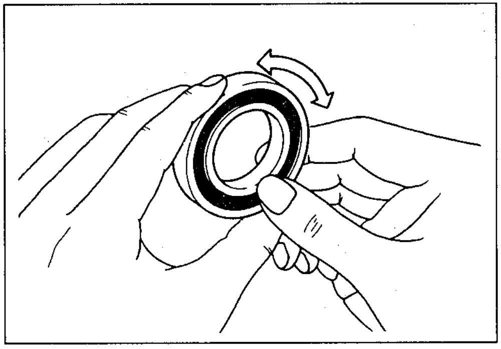
Hold the rectifier leads between the rectifier and the soldering iron with the long nose pliers. This will protect the rectifier from the heat.

INSPECTION AND REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

ROTOR AND BEARING

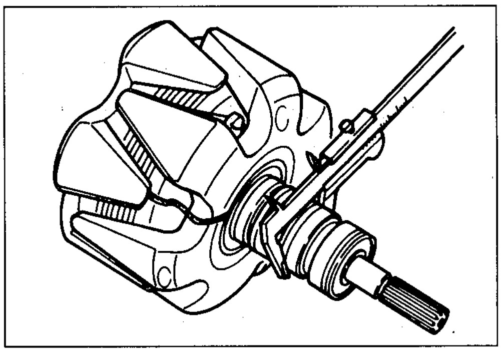
Check the face of the slip rings for contamination and roughness. If found to be roughened, dress with a fine sand paper (#500 — 600). If found to be contaminated, clean with a cloth saturated with alcohol.



Ball Bearing

Check that the ball bearings rotate smoothly.

If the ball bearings are noisy, they must be replaced.

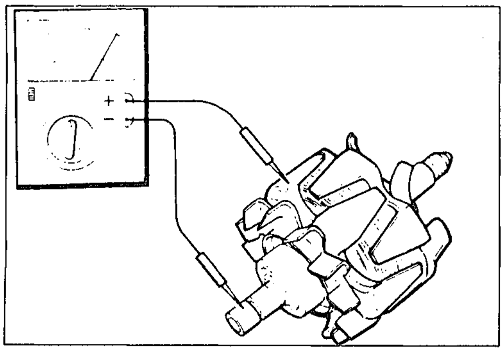


Use a vernier caliper to measure the slip ring outside diameter.

If the measured value exceeds the limit, the rotor must be replaced.

Slip Ring Outside Diameter mm(in.)

Standard	Limit
31.6 (1.24)	30.6 (1.20)



Rotor Coil Continuity Test

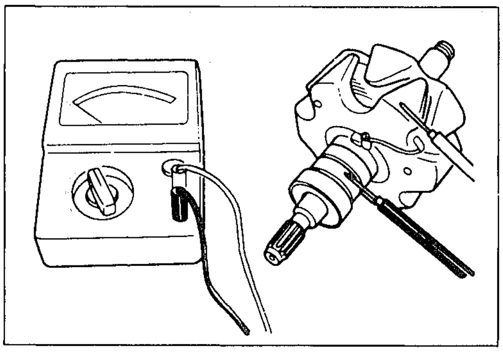
Use an circuit tester to test the rotor coil continuity.

1. Touch both circuit tester probes to the rotor coil slip rings.
2. Note the circuit tester reading.

   The circuit tester should register approximately 9 ohms.
3. If the circuit tester does not show continuity, check the connections between the lead wire and the slip rings.

   If breaks are founded, repair and repeat the rotor coil continuity test.

   If there is still no rotor coil continuity, the rotor must be replaced.



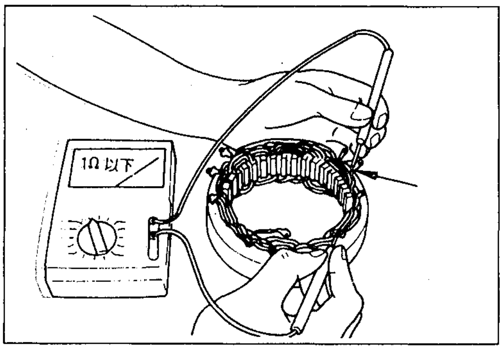
Rotor Coil Ground Test

Use an circuit tester to test the rotor coil for grounding.

1. Touch one of the circuit tester probes to the rotor shaft.
2. Touch the other circuit tester probe to one of slip rings.
3. Note the circuit tester reading.
4. Touch the circuit tester probe to the other slip ring.
5. Note the circuit tester reading.

   The circuit tester should show infinity (no needle movement) at both measuring points.

   If the circuit tester does not show infinity (the needle moves) at both measuring points, the rotor is grounded and must be replaced.



STATOR COIL

Stator Coil Continuity Test

Use an circuit tester to test the stator coil continuity.

1. Touch the circuit tester probes to two of the bare stator wires.
2. Note the circuit tester reading.
3. Move one of the circuit tester probes to a third wire.

4. Note the circuit tester reading.

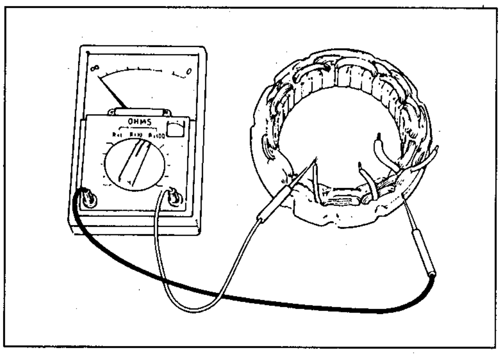
   If the two readings (Steps 2 and 4) are identical, the stator coil has continuity.

   If the two circuit tester readings are different, there is no stator continuity.

5. Check the neutral junction (arrow mark) for breaks.

   If breaks are found, repair and repeat the stator coil continuity test.

   If there is still no stator coil continuity, the stator must be replaced.



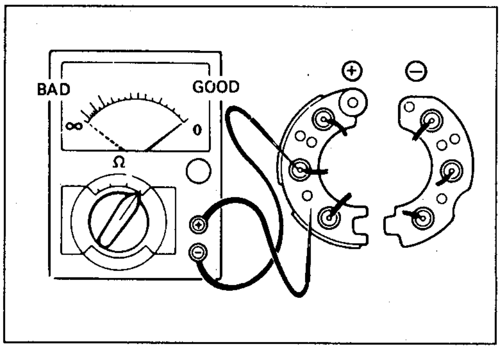
Stator Coil Ground Test

Use an circuit tester to test the stator coil for grounding.

1. Touch one circuit tester grobe to the bear metal surface of the stator.
2. Touch the other circuit tester probe to a bare stator lead wire.
3. Note the circuit tester reading.

   The circuit tester should show infinity (no needle movement).

   If the circuit tester shows a value other than infinity (the needle moves), the stator is grounded and must be replaced.



RECTIFIER

Rectifier (Positive Diode) Continuity Test

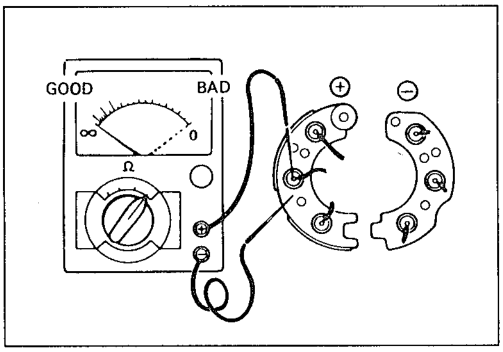
Use an circuit tester to test rectifier continuity.

1. Touch the circuit tester positive probe to the rectifier holder.
2. Touch the circuit tester negative probe to each of the diode terminals in turns.

3. Note the meter reading for each diode terminal.

   All of the diode should show continuity.

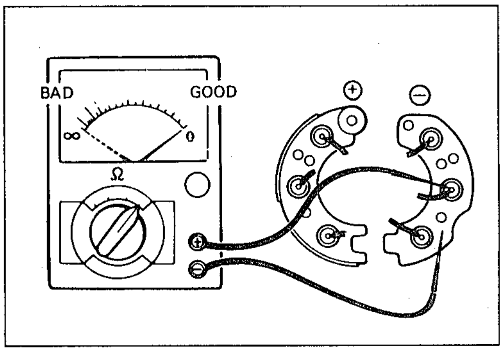
   If a diode shows no continuity, it is open circuit. The rectifier assembly must be replaced.



4. Touch the circuit tester negative probe to the rectifier holer.
5. Touch the circuit tester positive probe to each of the diode terminals in turn.
6. Note the meter reading for each diode terminal.

   None of the diodes should show continuity.

   If a diode shows continuity, it is shorted. The rectifier assembly must be replaced.



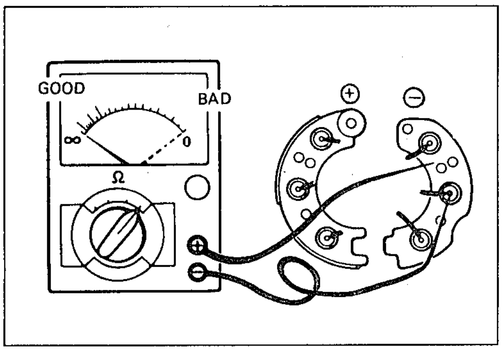
Rectifier (Negative Diode) Continuity Test

Use a circuit tester to test the rectifier continuity.

1. Touch the circuit tester negative probe to the rectifier holder.
2. Touch the circuit tester positive probe to each of the diode terminals in turn.
3. Note the meter reading for each diode terminal.

   All of the diode should show continuity.

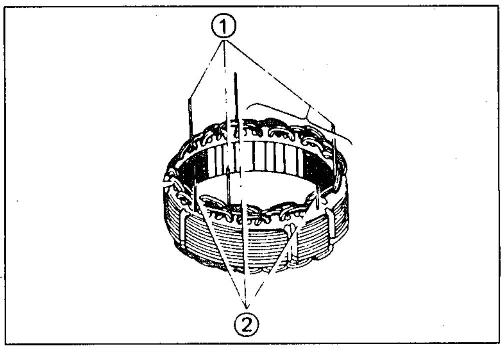
   If a diode shows no continuity, it is open. The rectifier assembly must be replaced.



4. Touch the circuit tester positive probe to the rectifier holder.
5. Touch the circuit tester negative probe to each of the diode terminals in turn.
6. Note the meter reading for each diode terminal.

   None of the diode should show continuity.

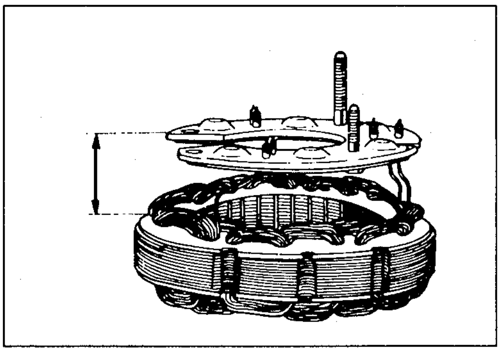
   If a diode shows continuity, it is shorted. The rectifier assembly must be replaced.



Rectifier Assembly Replacement Procedure

Use the Rectifier Service Kit to replace the rectifier assembly in the following steps.

1. Connect the three inside lead wires to the "N" terminals ①.
2. Connect the three outside lead wires ② to the outside terminals.
3. Wind the stator lead wires around the rectifier lead wires (included in the Rectifier Service Kit) and solder them.



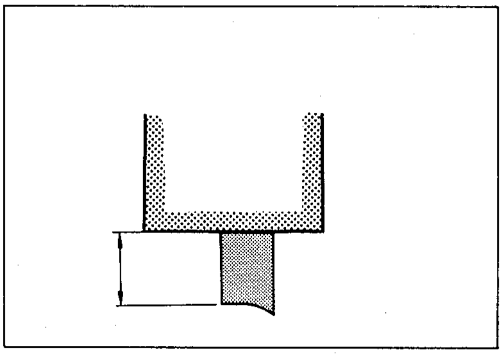
Note:

1. **The stator lead wires must be cut to the proper length before they are connected to the ractifier lead wires. If the stator lead wires are too long or too short, trouble may occur.**

Stator Lead Wire Length mm(in.)

33.5 (1.32)

2. **Take care not to damage the rectifier paint surfaces.**



BRUSH

Use a vernier caliper to measure the brush.

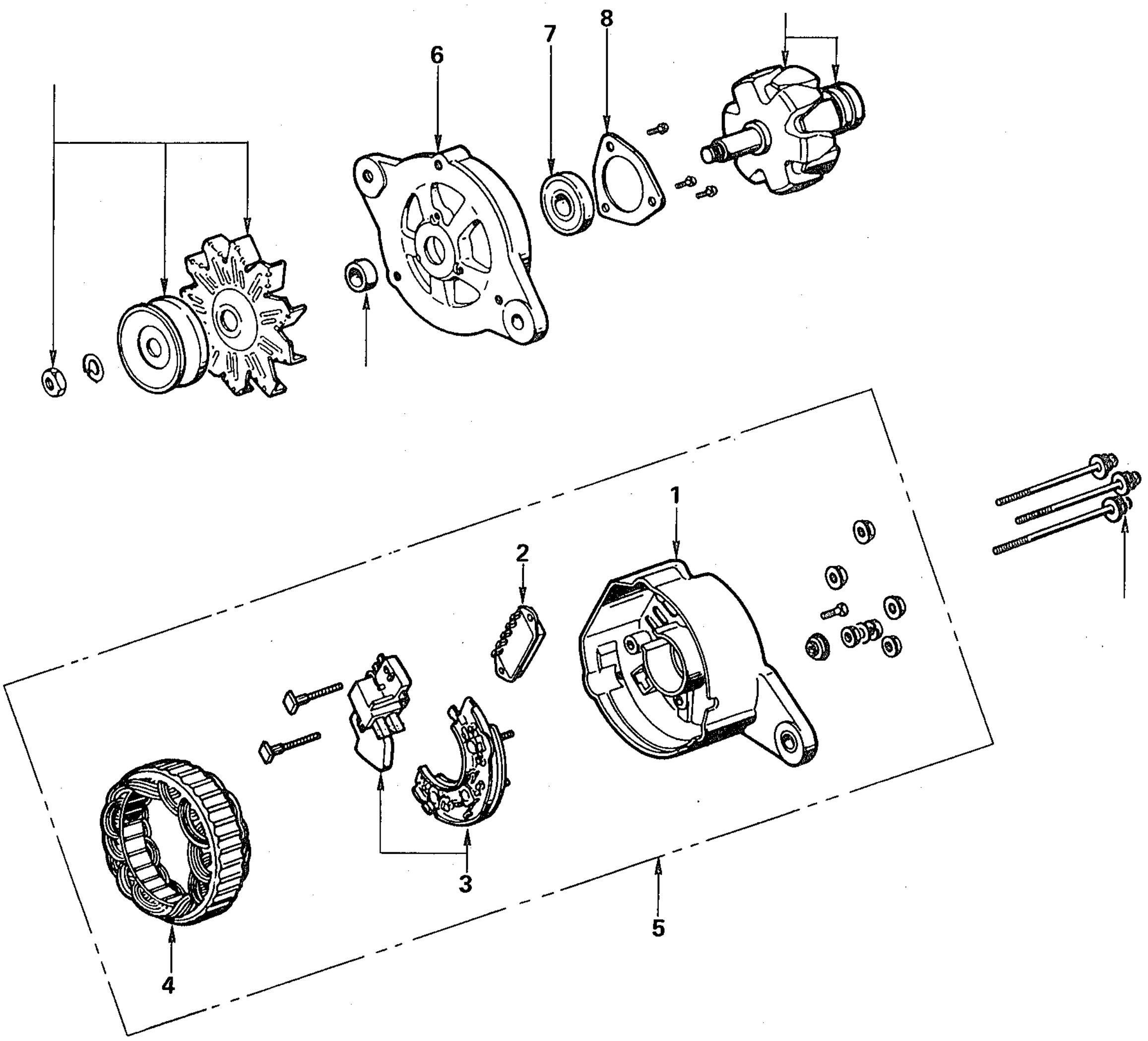
If the measured value exceeds the limit, the brush must be replaced.

Brush Length mm(in.)

	Standard	Limit
8-94423-756-0	14.5 (0.57)	7.5 (0.30)
8-94431-560-0	16.0 (0.63)	7.0 (0.28)
5-81200-335-0	14.5 (0.57)	7.5 (0.30)

Brushes are provided with a line which indicates the limit of usage.

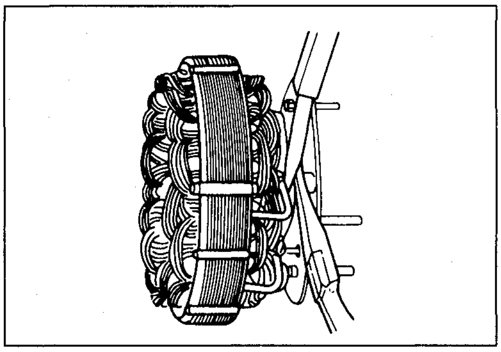
REASSEMBLY



Reassembly Steps

1. Rear cover
2. IC regulator
3. ▲ Rectifier with brush holder
4. ▲ Stator
5. Rear cover and stator
6. Front cover
7. ▲ Ball bearing
8. Bearing retainer
9. Rotor with bearing
10. Spacer collar
11. ▲ Pulley and fan
12. Through bolt

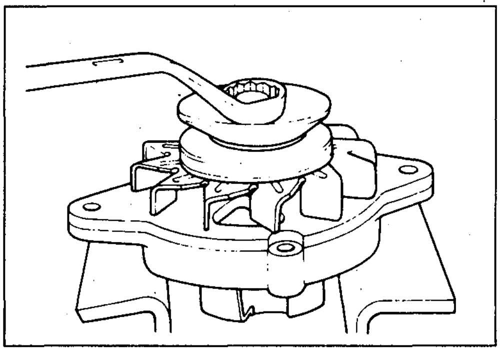
Important Operations



3. Rectifier with Brush Holder

4. Stator

When connecting stator coil leads and diode leads using solder, use long-nose pliers and finish the work as quickly as possible to prevent the heat from being transferred to the diodes.



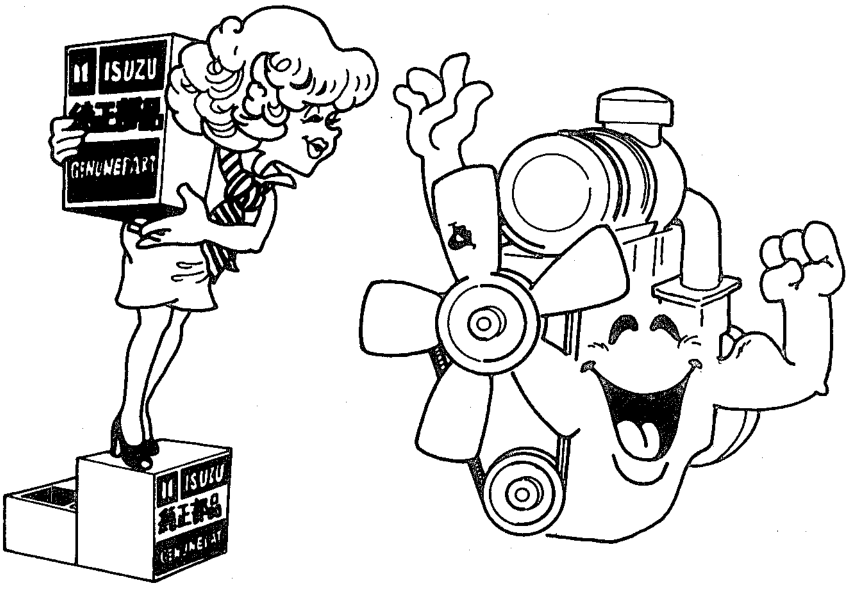
11. Pulley and Fan

Tighten the pulley and fan to the specified torque.

Pulley and Fan Nut Torque kg·m(lb.ft./N·m)
5.75 ± 0.75 (41.6 ± 5.4/56.4 ± 7.4)

MEMO

"QUALITY PARTS YOU CAN TRUST"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SECTION 10

TROUBLESHOOTING

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TROUBLESHOOTING

Refer to this Section to quickly diagnose and repair engine problems.

Each troubleshooting chart has three headings arranged from left to right.

(1) Checkpoint (2) Trouble Cause (3) Countermeasure

This Section is divided into ten sub-sections:

1. Hard Starting
    1) Starter motor inoperative
    2) Starter motor operates but engine does not turn over
    3) Engine turns over but does not start
2. Unstable Idling
3. Insufficient Power
4. Excessive Fuel Consumption
5. Excessive Oil Consumption
6. Overheating
7. White Exhaust Smoke
8. Dark Exhaust Smoke
9. Oil Pressure Does Not Rise
10. Abnormal Engine Noise

1. HARD STARTING

1. STARTER MOTOR INOPERATIVE

Checkpoint		Trouble Cause		Countermeasure
Neutral switch (If so equipped)	NG	Defective neutral switch	NG	Replace the neutral switch
Battery	NG	Loose battery cable terminals Poor connections due to rusting	NG	Clean and/or retighten the battery cable terminals
	NG	Battery discharged or weak	NG	Recharge or replace the battery
	NG	Fan belt loose or broken	NG	Adjust or replace the fan belt
OK				
Fusible link	NG	Fusible link shorted	NG	Replace the fusible link
OK				
Starter switch	NG	Defective starter switch or starter relay	NG	Replace the starter switch or the starter relay
OK				
Starter motor	NG	Defective magnetic switch or starter relay	NG	Repair or replace the magnetic switch
OK				
Starter motor	NG	Defective starter motor	NG	Repair or replace the starter motor

1. HARD STARTING

2. STARTER MOTOR OPERATES BUT ENGINE DOES NOT TURN OVER

Checkpoint		Trouble Cause		Countermeasure
Battery	NG	Loose battery cable terminals Poor connections due to rusting	NG	Clean and/or retighten the battery cable terminals
	NG	Battery discharged or weak	NG	Recharge or replace the battery
	NG	Fan belt loose or broken	NG	Adjust or replace the fan belt
OK				
Starter motor	NG	Defective pinion gear	NG	Replace the pinion gear
	NG	Defective magnetic switch	NG	Repair or replace the magnetic switch
	NG	Brush wear Weak brush spring	NG	Replace the brush and/or the brush spring
OK				
Engine	NG	Piston, crank bearing seizure, or other damage	NG	Repair or replace the related parts

1. HARD STARTING

3. ENGINE TURNS OVER BUT DOES NOT START

Checkpoint		Trouble Cause		Countermeasure
Engine stop mechanism	NG	Defective engine stop mechanism Control wire improperly adjusted (In line pump)	NG	Replace the engine stop mechanism Adjust the control wire
	NG	Defective fuel cut solenoid valve (VE pump)	NG	Replace the fuel cut solenoid valve

FUEL IS NOT BEING DELIVERED TO THE INJECTION PUMP

Checkpoint		Trouble Cause		Countermeasure
Fuel	NG	Fuel tank is empty	NG	Fill the fuel tank
OK				
Fuel piping	NG	Clogged or damaged fuel lines Loose fuel line connections	NG	Repair or replace the fuel lines Retighten the fuel line connections
OK				
Fuel filter	NG	Fuel filter overflow valve does not close	NG	Repair or replace the fuel filter overflow valve
	NG	Clogged fuel filter element	NG	Replace the fuel filter element or the fuel filter cartridge
OK				
Fuel system	NG	Air in the fuel system	NG	Bleed the air from the fuel system

Continued on the next page

1. HARD STARTING

3. ENGINE TURNS OVER BUT DOES NOT START

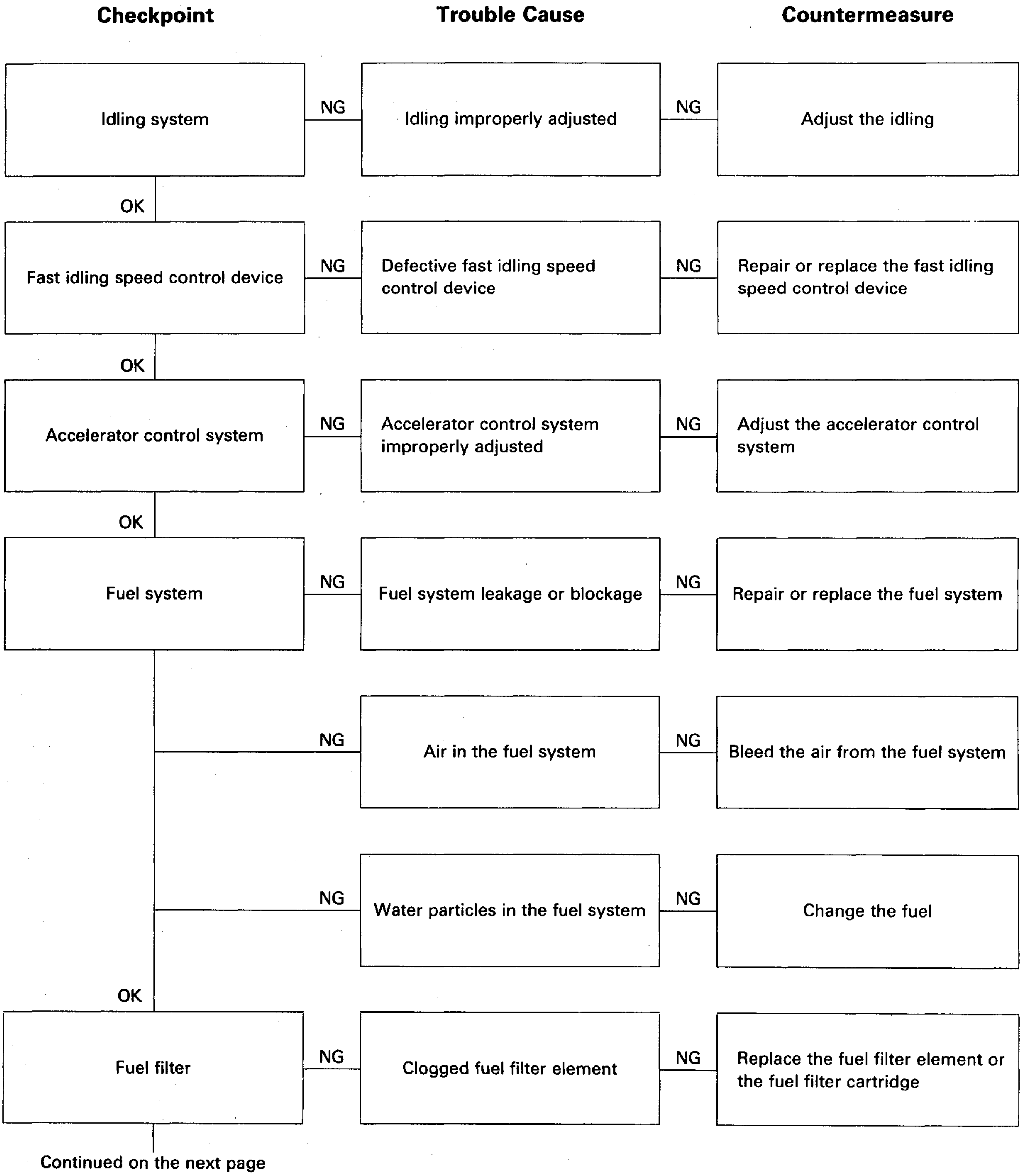
FUEL IS BEING DELIVERED TO THE INJECTION PUMP

Continued from the previous page

OK

Checkpoint		Trouble Cause		Countermeasure
Injection nozzle	NG	Injection nozzle injection starting pressure too low Improper spray condition	NG	Adjust or replace the injection nozzle
OK				
Injection pump	NG	Defective fuel injection nozzle resulting in fuel drippage after fuel injection	NG	Replace the delivery valve
	NG	Defective injection pump control rack operation	NG	Repair or replace the injection pump control rack
	NG	Injection pump plunger worn or stuck	NG	Replace the injection pump plunger assembly
OK				
Injection pump (VE pump)	NG	Injection pump drive shaft seizure or other damage	NG	Replace the injection pump drive shaft
	NG	Injection pump governor spring seizure	NG	Replace the injection pump governor spring

2. UNSTABLE IDLING



Checkpoint	Trouble Cause	Countermeasure
Idling system	Idling improperly adjusted	Adjust the idling
Fast idling speed control device	Defective fast idling speed control device	Repair or replace the fast idling speed control device
Accelerator control system	Accelerator control system improperly adjusted	Adjust the accelerator control system
Fuel system	Fuel system leakage or blockage	Repair or replace the fuel system
	Air in the fuel system	Bleed the air from the fuel system
	Water particles in the fuel system	Change the fuel
Fuel filter	Clogged fuel filter element	Replace the fuel filter element or the fuel filter cartridge

Continued on the next page

2. UNSTABLE IDLING

Continued from the previous page

OK

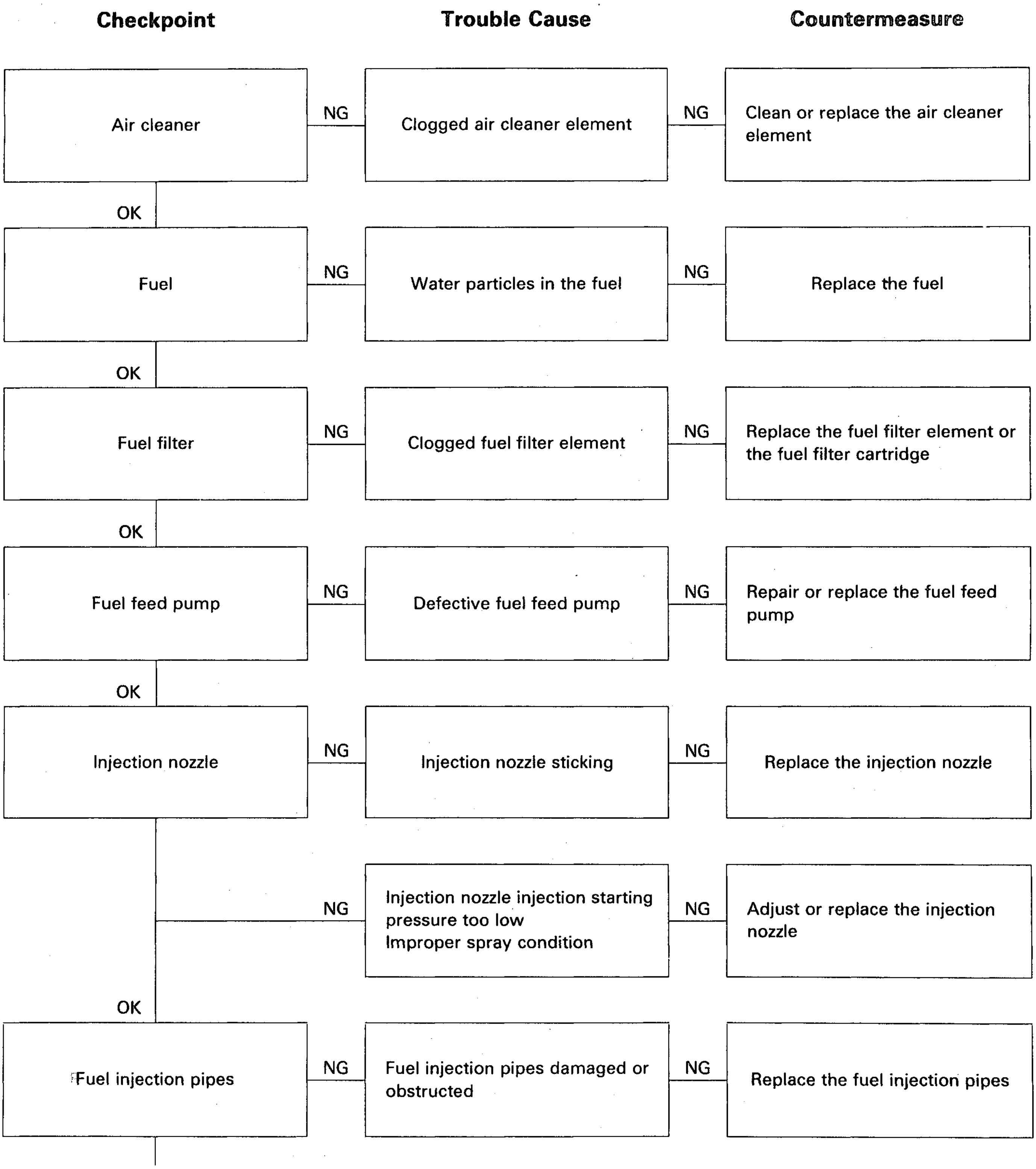
Checkpoint		Trouble Cause		Countermeasure
Injection pump	NG	Defective governor lever operation	NG	Repair or replace the governor lever
	NG	Regulator valve improperly adjusted (VE pump only)	NG	Adjust or replace the regulator valve
	NG	Broken plunger spring	NG	Replace the plunger spring
	NG	Worn plunger	NG	Replace the plunger assembly
	NG	Worn camshaft (In-line pump only)	NG	Replace the camshaft
	NG	Worn roller tappet (In-line pump only)	NG	Replace the roller tappet
	NG	Worn cam disc (VE pump only)	NG	Replace the cam disc

Continued on the next page

2. UNSTABLE IDLING

Checkpoint		Trouble Cause		Countermeasure
Continued from the previous page				
OK				
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance
OK				
Compression pressure	NG	Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	NG	Replace the related parts

3. INSUFFICIENT POWER


Checkpoint
Trouble Cause
Countermeasure
Air cleaner
NG
Clogged air cleaner element
NG
Clean or replace the air cleaner element
OK
Fuel
NG
Water particles in the fuel
NG
Replace the fuel
OK
Fuel filter
NG
Clogged fuel filter element
NG
Replace the fuel filter element or the fuel filter cartridge
OK
Fuel feed pump
NG
Defective fuel feed pump
NG
Repair or replace the fuel feed pump
OK
Injection nozzle
NG
Injection nozzle sticking
NG
Replace the injection nozzle
NG
Injection nozzle injection starting pressure too low
Improper spray condition
NG
Adjust or replace the injection nozzle
OK
Fuel injection pipes
NG
Fuel injection pipes damaged or obstructed
NG
Replace the fuel injection pipes

Continued on the next page

3. INSUFFICIENT POWER

Continued from the previous page

OK

Checkpoint		Trouble Cause		Countermeasure
Injection pump	NG	Defective regulating valve (VE pump only)	NG	Repair or replace the regulating valve
	NG	Defective delivery valve	NG	Replace the delivery valve
	NG	Defective timer	MG	Repair or replace the timer
	NG	Worn cam disk (VE pump only)	NG	Replace the cam disk
	NG	Improper control lever operation	NG	Adjust or replace the control lever
	NG	Defective injection timing	NG	Adjust the injection timing Repair or replace the injection pump timer
	NG	Weak governor spring	NG	Replace the governor spring

Continued on the next page

3. INSUFFICIENT POWER

Continued from the previous page

OK

Checkpoint		Trouble Cause		Countermeasure
Injection pump	NG	Worn plunger	NG	Replace the plunger assembly
	NG	Worn camshaft (In-line pump only)	NG	Replace the camshaft
	NG	Worn roller tappet (In-line pump only)	NG	Replace the roller tappet
	NG	Worn cam disc (VE pump only)	NG	Replace the cam disc
OK				
Turbocharger	NG	Booster compensator pipe broken or cracked	NG	Replace the booster compensator pipe
	NG	Exhaust gas leakage from the exhaust system Air leakage from the intake system	NG	Repair or replace the related parts
	NG	Defective power echo gate	NG	Repair or replace the power echo gate

Continued on the next page

3. INSUFFICIENT POWER

Continued from the previous page

Checkpoint		Trouble Cause		Countermeasure
Turbocharger	NG	Defective turbocharger assembly	NG	Replace the turbocharger assembly
OK				
Compression pressure	NG	Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	NG	Replace the related parts
OK				
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance
OK				
Valve spring	NG	Valve spring weak or broken	NG	Replace the valve spring
OK				
Exhaust system	NG	Exhaust pipe clogged	NG	Clean the exhaust pipe
OK				
Full load adjusting screw seal	NG	Open and improperly set adjusting screw seal	NG	Adjust and reseal the adjusting screw

4. EXCESSIVE FUEL CONSUMPTION

Checkpoint		Trouble Cause		Countermeasure
Fuel system	NG	Fuel leakage	NG	Repair or replace the fuel system related parts
OK				
Air cleaner	NG	Clogged air cleaner element	NG	Clean or replace the air cleaner element
OK				
Idling speed	NG	Poorly adjusted idling speed	NG	Adjust the idling speed
OK				
Injection nozzle	NG	Injection nozzle injection starting pressure too low Improper spray condition	NG	Adjust or replace the injection nozzle
OK				
Fuel injection timing	NG	Fuel injection timing improperly adjusted	NG	Adjust the fuel injection timing
OK				
Injection pump	NG	Defective delivery valve resulting is fuel drippage after fuel injection	NG	Replace the delivery valve
OK				
Turbocharger	NG	Air leakage from the turbocharger intake side	NG	Repair the turbocharger intake side

Continued on the next page

4. EXCESSIVE FUEL CONSUMPTION

Continued from the previous page

Checkpoint	Trouble Cause	Countermeasure
Turbocharger	Defective turbocharger assembly	Replace the turbocharger assembly
Valve clearance	Valve clearance improperly adjusted	Adjust the valve clearance
Compression pressure	Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	Replace the related parts
Valve spring	Valve spring weak or broken	Replace the valve spring

5. EXCESSIVE OIL CONSUMPTION

Checkpoint		Trouble Cause		Countermeasure
Engine oil	NG	Engine oil unsuitable Too much engine oil	NG	Replace the engine oil Correct the engine oil volume
OK				
Oil seal and gasket	NG	Oil leakage from the oil seal and/or the gasket	NG	Replace the oil seal and/or the gasket
OK				
Air breather	NG	Clogged air breather	NG	Clean the air breather
OK				
Inlet and exhaust valves Valve seals	NG	Defective valve seals Worn valves stems and valve guides	NG	Replace the valve seals, the valves, and the valve guides
OK				
Piston rings	NG	Piston rings worn, broken or improperly installed	NG	Replace the piston rings or properly install
OK				
Cylinder liners	NG	Cylinder lines scored or worn	NG	Replace the cylinder liners

6. OVERHEATING

Checkpoint		Trouble Cause		Countermeasure
Cooling water	NG	Insufficient cooling water	NG	Replenish the cooling water
OK				
Fan coupling (if so equipped)	NG	Oil leakage from the fan coupling	NG	Replace the fan coupling
OK				
Fan belt	NG	Fan belt loose or cracked causing slippage	NG	Replace the fan belt
OK				
Radiator	NG	Defective radiator cap or clogged radiator core	NG	Replace the radiator cap or clean the radiator core
OK				
Water pump	NG	Defective water pump	NG	Repair or replace the water pump
OK				
Cylinder head and cylinder body sealing cap	NG	Defective sealing cap resulting in water leakage	NG	Replace the sealing cap
OK				
Thermostat	NG	Defective thermostat	NG	Replace the thermostat

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6. OVERHEATING

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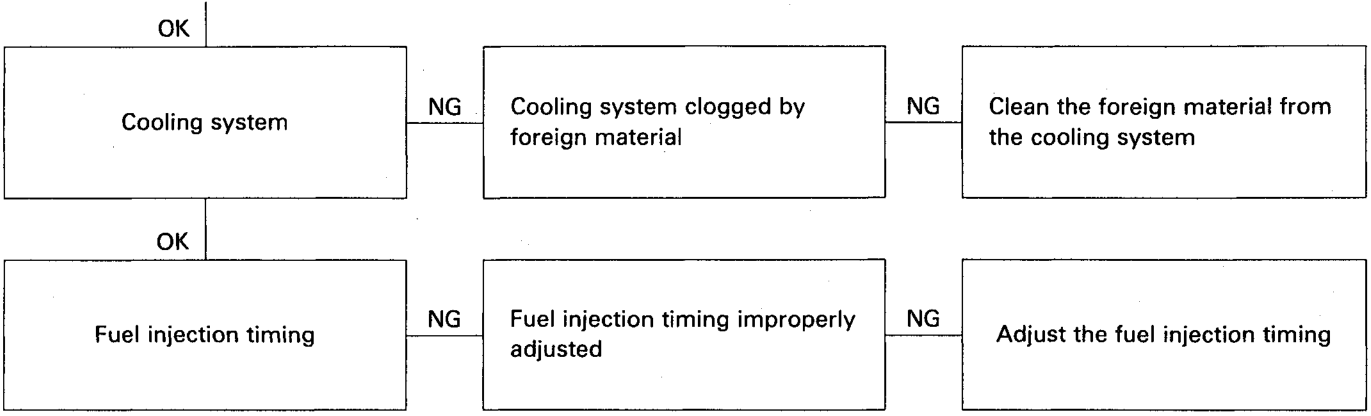


Checkpoint	Trouble Cause	Countermeasure
Cooling system	Cooling system clogged by foreign material	Clean the foreign material from the cooling system
Fuel injection timing	Fuel injection timing improperly adjusted	Adjust the fuel injection timing

7. WHITE EXHAUST SMOKE

Checkpoint		Trouble Cause		Countermeasure
Fuel	NG	Water particles in the fuel	NG	Replace the fuel
OK				
Fuel injection timing	NG	Delayed fuel injection timing	NG	Adjust the fuel injection timing
OK				
Compression pressure	NG	Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	NG	Replace the related parts
OK				
Turbocharger	NG	Defective turbocharger	NG	Replace the turbocharger
OK				
Inlet and exhaust valves Valve seals	NG	Defective valve seals Worn valves stems and valve guides	NG	Replace the valve seals, the valves, and the valve guides
OK				
Piston rings	NG	Piston rings worn, broken or improperly installed	NG	Replace the piston rings or properly install
OK				
Cylinder liners	NG	Cylinder lines scored or worn	NG	Replace the cylinder liners

8. DARK EXHAUST SMOKE

Checkpoint	Trouble Cause	Countermeasure
Air cleaner	Clogged air cleaner element	Clean or replace the air cleaner element
Injection nozzle	Injection nozzle injection starting pressure too low Improper spray condition	Adjust or replace the injection nozzle
Fuel injection timing	Fuel injection timing improperly adjusted	Adjust the fuel injection timing
Injection pump	Defective delivery valve resulting in fuel drippage after fuel injection	Replace the delivery valve
	Excessive injection volume	Adjust the injection volume

9. OIL PRESSURE DOES NOT RISE

Checkpoint	Trouble Cause	Countermeasure
Engine oil	Improper viscosity engine oil Too much engine oil	Replace the engine oil Correct the engine oil volume
Oil pressure gauge or unit Oil pressure indicator light	Defective oil pressure gauge or unit Defective indicator light	Repair or replace the oil pressure gauge or unit Replace the indicator light
Oil filter	Clogged oil filter element	Replace the oil filter element or the oil filter cartridge
Relief valve and by-pass valve	Relief valve sticking and/or weak by-pass valve spring	Replace the relief valve and/or the by-pass valve spring
Oil pump	Clogged oil pump strainer	Clean the oil pump strainer
	Worn oil pump related parts	Replace the oil pump related parts
Rocker arm shaft	Worn rocker arm bushing	Replace the rocker arm bushing

Continued on the nest page

9. OIL PRESSURE DOES NOT RISE

Continued from the previous page

Checkpoint		Trouble Cause		Countermeasure
OK				
Camshaft	NG	Worn camshaft and camshaft bearing	NG	Replace the camshaft and the camshaft bearings
OK				
Crankshaft and bearings	NG	Worn crankshaft and bearings	NG	Replace the crankshaft and/or the bearings

10. ABNORMAL ENGINE NOISE

1. Engine Knocking

Check to see that the engine has been thoroughly warmed up before beginning the troubleshooting procedure.

Checkpoint		Trouble Cause		Countermeasure
Fuel	NG	Fuel unsuitable	NG	Replace the fuel
OK				
Fuel injection timing	NG	Fuel injection timing improperly adjusted	NG	Adjust the fuel injection timing
OK				
Injection nozzle	NG	Improper injection nozzle starting pressure and spray condition	NG	Adjust or replace the injection nozzle
OK				
Compression pressure	NG	Blown out head gasket Broken piston ring	NG	Replace the head gasket or the piston ring

2. Gas Leakage Noise

Exhaust pipes	NG	Loosely connected exhaust pipes Broken exhaust pipes	NG	Tighten the exhaust pipe connections Replace the exhaust pipes
OK				
Injection nozzles and/or glow plugs	NG	Loose injection nozzles and/or glow plugs	NG	Replace the washers Tighten the injection nozzles and/or the glow plugs

Continued on the next page

10. ABNORMAL ENGINE NOISE

2. Gas Leakage Noise

Continued from the previous page

OK

Checkpoint		Trouble Cause		Countermeasure
Exhaust manifold	NG	Loosely connected exhaust manifold and/or glow plugs	NG	Tighten the exhaust manifold connections
OK				
Cylinder head gasket	NG	Damaged cylinder head gasket	NG	Replace the cylinder head gasket

3. Continuous Noise

Checkpoint		Trouble Cause		Countermeasure
Fan belt	NG	Loose fan belt	NG	Readjust the fan belt tension
OK				
Cooling fan	NG	Loose cooling fan	NG	Retighten the cooling fan
OK				
Water pump bearing	NG	Worn or damaged water pump bearing	NG	Replace the water pump bearing
OK				
Alternator or vacuum pump	NG	Defective alternator or vacuum pump	NG	Repair or replace the alternator or the vacuum pump
OK				
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance

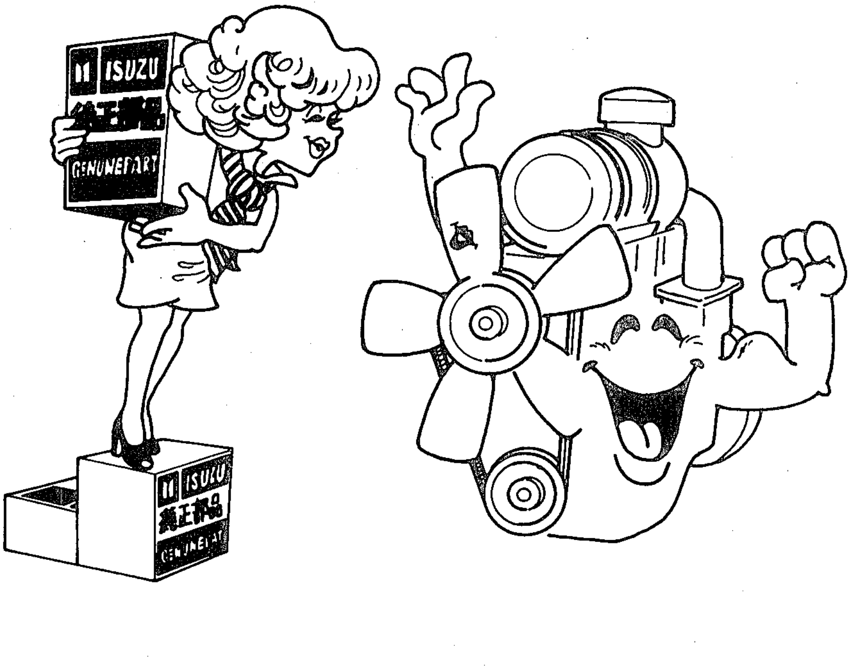
10. ABNORMAL ENGINE NOISE

4. Slapping Noise

Checkpoint		Trouble Cause		Countermeasure
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance
OK				
Rocker arm	NG	Damaged rocker arm	NG	Replace the rocker arm
OK				
Flywheel	NG	Loose flywheel bolts	NG	Retighten the flywheel bolts
OK				
Crankshaft and thrust bearings	NG	Worn or damaged crankshaft and/or thrust bearings	NG	Replace the crankshaft and/or the thrust bearings
OK				
Crankshaft and connecting rod bearings	NG	Worn or damaged crankshaft and/or connecting rod bearings	NG	Replace the crankshaft and/or the connecting rod bearings
OK				
Connecting rod bushing and piston pin	NG	Worn or damaged connecting rod bushing and piston pin	NG	Replace the connecting rod bushing and/or the piston pin
OK				
Piston and cylinder liner	NG	Worn or damaged piston and cylinder liner Foreign material in the cylinder	NG	Replace the piston and the cylinder liner

MEMO

"QUALITY PARTS YOU CAN TRUST"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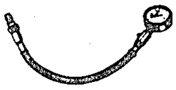
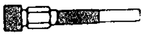
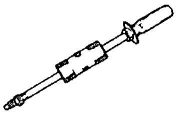
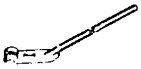
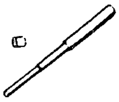
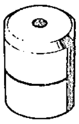
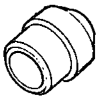
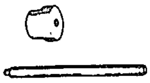
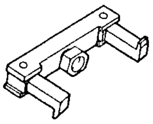
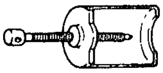
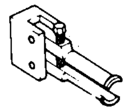
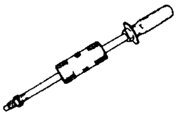
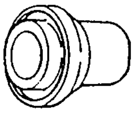
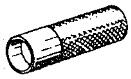
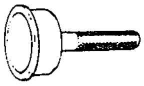
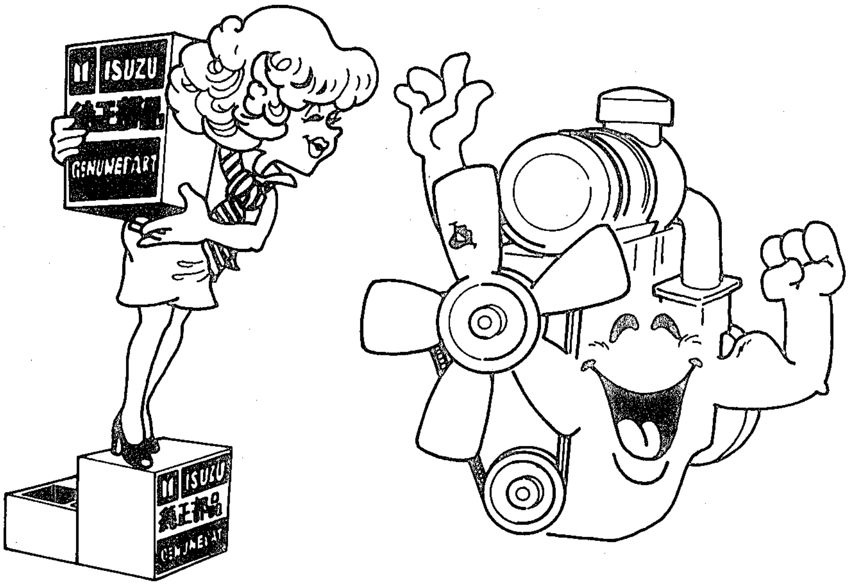
SPECIAL TOOL LIST

ITEM NO.	ILLUSTRATION	PART NO.	PARTS NAME	PAGE
1		5-8840-2008-1	Compression Gauge	2— 9
2		5-8531-7001-0	Compression Gauge Adaptor	2— 9
3		5-8840-0019-0	Sliding Hammer	3— 7
4		9-8523-1423-0	Valve Spring Compressor	3—14 5— 5
5		9-8523-1212-0	Valve Guide Replacer	4— 3 4— 4
6		5-8840-2039-0 (for 4JA.B1) 5-8840-9021-0 (for 4JC1)	Cylinder Liner Remover	4—11
7		5-8840-2040-0 (for 4JA.B1) 5-8840-9022-0 (for 4JC1)	Cylinder Liner Installer	4—12
8		5-8840-2038-0	Camshaft Bearing Replacer	4—17 4—18
9		5-8840-0086-0	Camshaft Timing Gear Universal Puller	3—18 4—18
10		9-8840-2057-0	Crankshaft Timing Gear Remover	4—24

ITEM NO.	ILLUSTRATION	PART NO.	PARTS NAME	PAGE
11		9-8522-0020-0	Crankshaft Timing Gear Installer	4—24 4—25
12		5-8840-2000-0	Crankshaft Pilot Bearing Remover	4—25
13		5-8840-0019-0	Sliding Hammer	4—25
14		5-8522-0024-0	Crankshaft Pilot Bearing Installer	4—25
15		5-8840-2061-0	Crankshaft Front Oil Seal Installer	4—33
16		5-8840-2033-0	Valve Stem Oil Seal Installer	5—5
17		5-8840-0141-0	Crankshaft Rear Oil Seal Installer	5—18

MEMO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APPENDIX A

CONVERSION TABLES

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LENGTH

MILLIMETERS TO INCHES

mm	in.	mm	in.	mm	in.	mm	in.
1	0.0394	26	1.0236	51	2.0079	76	2.9921
2	0.0787	27	1.0630	52	2.0472	77	3.0315
3	0.1181	28	1.1024	53	2.0866	78	3.0709
4	0.1575	29	1.1417	54	2.1260	79	3.1102
5	0.1969	30	1.1811	55	2.1654	80	3.1496
6	0.2362	31	1.2205	56	2.2047	81	3.1890
7	0.2756	32	1.2598	57	2.2441	82	3.2283
8	0.3150	33	1.2992	58	2.2835	83	3.2677
9	0.3543	34	1.3386	59	2.3228	84	3.3071
10	0.3937	35	1.3780	60	2.3622	85	3.3465
11	0.4331	36	1.4173	61	2.4016	86	3.3858
12	0.4724	37	1.4567	62	2.4409	87	3.4252
13	0.5118	38	1.4961	63	2.4803	88	3.4646
14	0.5512	39	1.5354	64	2.5197	89	3.5039
15	0.5906	40	1.5748	65	2.5591	90	3.5433
16	0.6299	41	1.6142	66	2.5984	91	3.5827
17	0.6693	42	1.6535	67	2.6378	92	3.6220
18	0.7087	43	1.6929	68	2.6772	93	3.6614
19	0.7480	44	1.7323	69	2.7165	94	3.7008
20	0.7874	45	1.7717	70	2.7559	95	3.7402
21	0.8268	46	1.8110	71	2.7953	96	3.7795
22	0.8661	47	1.8504	72	2.8346	97	3.8189
23	0.9055	48	1.8898	73	2.8740	98	3.8583
24	0.9449	49	1.9291	74	2.9134	99	3.8976
25	0.9843	50	1.9685	75	2.9528	100	3.9370

101	3.9764	111	4.3701	121	4.7638	131	5.1575
102	4.0157	112	4.4094	122	4.8031	132	5.1968
103	4.0551	113	4.4488	123	4.8425	133	5.2362
104	4.0945	114	4.4882	124	4.8819	134	5.2756
105	4.1339	115	4.5276	125	4.9213	135	5.3150
106	4.1732	116	4.5669	126	4.9606	136	5.3543
107	4.2126	117	4.6063	127	5.0000	137	5.3937
108	4.2520	118	4.6457	128	5.0394	138	5.4331
109	4.2913	119	4.6850	129	5.0787	139	5.4724

INCHES TO MILLIMETERS

in.	mm	in.	mm
1/64	0.3969	33/64	13.0969
1/32	0.7938	17/32	13.4938
3/64	1.1906	35/64	13.8906
1/16	1.5875	9/16	14.2875
5/64	1.9844	37/64	14.6844
3/32	2.3813	19/32	15.0813
7/64	2.7781	39/64	15.4781
1/8	3.1750	5/8	15.8750
9/64	3.5719	41/64	16.2719
5/32	3.9688	21/32	16.6688
11/64	4.3656	43/64	17.0656
3/16	4.7625	11/16	17.4625
13/64	5.1594	45/64	17.8594
7/32	5.5563	23/32	18.2563
15/64	5.9531	47/64	18.6531
1/4	6.3500	3/4	19.0500
17/64	6.7469	49/64	19.4469
9/32	7.1438	25/32	19.8438
19/64	7.5406	51/64	20.2406
5/16	7.9375	13/16	20.6375
21/64	8.3344	53/64	21.0344
11/32	8.7313	27/32	21.4313
23/64	9.1281	55/64	21.8281
3/8	9.5250	7/8	22.2250
25/64	9.9219	57/64	22.6219
13/32	10.3188	29/32	23.0188
27/64	10.7156	59/64	23.4156
7/16	11.1125	15/16	23.8125
29/64	11.5094	61/64	24.2094
15/32	11.9063	31/32	24.6063
31/64	12.3031	63/64	25.0031
1/2	12.7000	1	25.4000

A—2 CONVERSION TABLE

LENGTH

FEET TO METERS

ft.	0	1	2	3	4	5	6	7	8	9	ft.
	m	m	m	m	m	m	m	m	m	m	
—		0.305	0.610	0.914	1.219	1.524	1.829	2.134	2.438	2.743	—
10	3.048	3.353	3.658	3.962	4.267	4.572	4.877	5.182	5.486	5.791	10
20	6.096	6.401	6.706	7.010	7.315	7.620	7.925	8.230	8.534	8.839	20
30	9.144	9.449	9.754	10.058	10.363	10.668	10.973	11.278	11.582	11.887	30
40	12.192	12.497	12.802	13.106	13.411	13.716	14.021	14.326	14.630	14.935	40
50	15.240	15.545	15.850	16.154	16.459	16.764	17.069	17.374	17.678	17.983	50
60	18.288	18.593	18.898	19.202	19.507	19.812	20.117	20.422	20.726	21.031	60
70	21.336	21.641	21.946	22.250	22.555	22.860	23.165	23.470	23.774	24.079	70
80	24.384	24.689	24.994	25.298	25.603	25.908	26.213	26.518	26.822	27.127	80
90	27.432	27.737	28.042	28.346	28.651	28.956	29.261	29.566	29.870	30.175	90
100	30.480	30.785	31.090	31.394	31.699	32.004	32.309	32.614	32.918	33.223	100

METERS TO FEET

m	0	1	2	3	4	5	6	7	8	9	m
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	
—		3.2808	6.5617	9.8425	13.1234	16.4042	19.6850	22.9659	26.2467	29.5276	—
10	32.8084	36.0892	39.3701	42.6509	45.9318	49.2126	52.4934	55.7743	59.0551	62.3360	10
20	65.6168	68.8976	72.1785	75.4593	78.7402	82.0210	85.3018	88.5827	91.8635	95.1444	20
30	98.4252	101.7060	104.9869	108.2677	111.5486	114.8294	118.1102	121.3911	124.6719	127.9528	30
40	131.2336	134.5144	137.7953	141.0761	144.3570	147.6378	150.9186	154.1995	175.4803	160.7612	40
50	164.0420	167.3228	170.6037	173.8845	177.1654	180.4462	183.7270	187.0079	190.2887	193.5696	50
60	196.8504	200.1312	203.4121	206.6929	209.9738	213.2546	216.5354	219.8163	223.0971	226.3780	60
70	229.6588	232.9396	236.2205	239.5013	242.7822	246.0630	249.3438	252.6247	255.9055	259.1864	70
80	262.4672	265.7480	269.0289	272.3097	275.5906	278.8714	282.1522	285.4331	288.7139	291.9948	80
90	295.2756	298.5564	301.8373	305.1181	308.3990	311.6798	314.9606	318.2415	321.5223	324.8032	90
100	328.0840	331.3648	334.6457	337.9265	341.2074	344.4882	347.7690	351.0499	354.3307	357.6116	100

MILES TO KILOMETERS

miles	0	1	2	3	4	5	6	7	8	9	miles
	km	km	km	km	km	km	km	km	km	km	
—		1.609	3.219	4.828	6.437	8.047	9.656	11.265	12.875	14.484	—
10	16.093	17.703	19.312	20.921	22.531	24.140	25.750	27.359	28.968	30.578	10
20	32.187	33.796	35.406	37.015	38.624	40.234	41.843	43.452	45.062	46.671	20
30	48.280	49.890	51.499	53.108	54.718	56.327	57.936	59.546	61.155	62.764	30
40	64.374	65.983	67.592	69.202	70.811	72.420	74.030	75.639	77.249	78.858	40
50	80.467	82.077	83.686	85.295	86.905	88.514	90.123	91.733	93.342	94.951	50
60	96.561	98.170	99.779	101.389	103.000	104.607	106.217	107.826	109.435	111.045	60
70	112.654	114.263	115.873	117.482	119.091	120.700	122.310	123.919	125.529	127.138	70
80	128.748	130.357	131.966	133.576	135.185	136.794	138.404	140.013	141.622	143.232	80
90	144.841	146.450	148.060	149.669	151.278	152.888	154.497	156.106	157.716	159.325	90
100	160.934	162.544	164.153	165.762	167.372	168.981	170.590	172.200	173.809	175.418	100

KILOMETERS TO MILES

km	0	1	2	3	4	5	6	7	8	9	km
	miles	miles	miles	miles	miles	miles	miles	miles	miles	miles	
—		0.621	1.243	1.864	2.485	3.107	3.728	4.350	4.971	5.592	—
10	6.214	6.835	7.456	8.078	8.699	9.321	9.942	10.563	11.185	11.806	10
20	12.427	13.049	13.670	14.292	14.913	15.534	16.156	16.777	17.398	18.020	20
30	18.641	19.262	19.884	20.505	21.127	21.748	22.370	22.990	23.612	24.233	30
40	24.855	25.476	26.098	26.719	27.340	27.962	28.583	29.204	29.826	30.447	40
50	31.065	31.690	32.311	32.933	33.554	34.175	34.797	35.418	36.039	36.661	50
60	37.282	37.904	38.525	39.146	39.768	40.389	41.010	41.632	42.253	42.875	60
70	43.496	44.117	44.739	45.360	45.981	46.603	47.224	47.845	48.467	49.088	70
80	49.711	50.331	50.952	51.574	52.195	52.816	53.438	54.059	54.681	55.302	80
90	55.923	56.545	57.166	57.187	58.409	59.030	59.652	60.273	60.894	61.516	90
100	62.137	62.758	63.380	64.001	64.622	65.244	65.865	66.487	67.108	67.729	100

AREA

SQUARE INCHES TO SQUARE CENTIMETERS

in²	0	1	2	3	4	5	6	7	8	9	in²
	cm²	cm²	cm²	cm²	cm²	cm²	cm²	cm²	cm²	cm²	
—		6.452	12.903	19.355	25.806	32.258	38.710	45.161	51.613	58.064	—
10	64.516	70.968	77.419	83.871	90.322	96.774	103.226	109.677	116.129	122.580	10
20	129.032	135.484	141.935	148.387	154.838	161.290	167.742	174.193	180.645	187.096	20
30	193.548	200.000	206.451	212.903	219.354	225.806	232.258	238.709	245.161	251.612	30
40	258.064	264.516	270.967	277.419	283.870	290.322	296.774	303.225	309.677	316.128	40
50	322.580	329.032	335.483	341.935	348.386	354.838	361.290	367.741	374.193	380.644	50
60	387.096	393.548	399.999	406.451	412.902	419.354	425.806	432.257	438.709	445.160	60
70	451.612	458.064	464.515	470.967	477.418	483.870	490.322	496.773	503.225	509.676	70
80	516.128	522.580	529.031	535.483	541.934	548.386	554.838	561.289	567.741	574.192	80
90	580.644	587.096	593.547	599.999	606.450	612.902	619.354	625.805	632.257	638.708	90
100	645.160	651.612	658.063	664.515	670.966	677.418	683.870	690.312	696.773	703.224	100

SQUARE CENTIMETERS TO SQUARE INCHES

cm²	0	1	2	3	4	5	6	7	8	9	cm²
	in²	in²	in²	in²	in²	in²	in²	in²	in²	in²	
—		0.155	0.310	0.465	0.620	0.775	0.930	1.085	1.240	1.395	—
10	1.550	1.705	1.860	2.015	2.170	2.325	2.480	2.635	2.790	2.945	10
20	3.100	3.255	3.410	3.565	3.720	3.875	4.030	4.185	4.340	4.495	20
30	4.650	4.805	4.960	5.115	5.270	5.425	5.580	5.735	5.890	6.045	30
40	6.200	6.355	6.510	6.665	6.820	6.975	7.130	7.285	7.440	7.595	40
50	7.750	7.905	8.060	8.215	8.370	8.525	8.680	8.835	8.990	9.145	50
60	9.300	9.455	9.610	9.765	9.920	10.075	10.230	10.385	10.540	10.695	60
70	10.850	11.005	11.160	11.315	11.470	11.625	11.780	11.935	12.090	12.245	70
80	12.400	12.555	12.710	12.865	13.020	13.175	13.330	13.485	13.640	13.795	80
90	13.950	14.105	14.260	14.415	14.570	14.725	14.880	15.035	15.190	15.345	90
100	15.500	15.655	15.810	15.965	16.120	16.275	16.430	16.583	16.740	16.895	100

VOLUME

CUBIC INCHES TO CUBIC CENTIMETERS

in³	0	1	2	3	4	5	6	7	8	9	in³
	cm³(cc)	cm³(cc)	cm³(cc)	cm³(cc)	cm³(cc)	cm³(cc)	cm³(cc)	cm³(cc)	cm³(cc)	cm³(cc)	
		16.387	32.774	49.161	65.548	81.935	98.322	114.709	131.097	147.484	—
10	163.871	180.258	196.645	213.032	229.419	245.806	262.193	278.580	294.967	311.354	10
20	327.741	344.128	360.515	376.902	393.290	209.677	426.064	442.451	458.838	475.225	20
30	491.612	507.999	524.386	540.773	557.160	573.547	589.934	606.321	622.708	639.095	30
40	655.483	671.870	688.257	704.644	721.031	737.418	753.805	770.192	786.579	802.966	40
50	819.353	835.740	852.127	868.514	884.901	901.289	917.676	934.063	950.450	966.837	50
60	983.224	999.611	1015.998	1032.385	1048.772	1065.159	1081.546	1097.933	1114.320	1130.707	60
70	1147.094	1163.482	1179.869	1196.256	1212.643	1229.030	1245.417	1261.804	1278.191	1294.578	70
80	1310.965	1327.352	1343.739	1360.126	1376.513	1392.900	1409.288	1425.675	1442.062	1458.449	80
90	1474.836	1491.223	1507.610	1523.997	1540.384	1556.771	1573.158	1589.545	1605.932	1622.319	90
100	1638.706	1655.093	1671.481	1687.868	1704.255	1720.642	1737.029	1753.416	1769.803	1786.190	100

CUBIC CENTIMETERS TO CUBIC INCHES

cm³(cc)	0	1	2	3	4	5	6	7	8	9	cm³(cc)
	in³	in³	in³	in³	in³	in³	in³	in³	in³	in³	
—		0.0610	0.1220	0.1831	0.2441	0.3051	0.3661	0.4272	0.4882	0.5492	—
10	0.6102	0.6713	0.7323	0.7933	0.8543	0.9153	0.9764	1.0374	1.0984	1.1594	10
20	1.2205	1.2815	1.3425	1.4035	1.4646	1.5256	1.5866	1.6476	1.7086	1.7697	20
30	1.8307	1.8917	1.9527	2.0138	2.0748	2.1358	2.1968	2.2579	2.1389	2.3799	30
40	2.4409	2.5020	2.5630	2.6240	2.6850	2.7460	2.8071	2.8681	2.9291	2.9901	40
50	3.0512	3.1122	3.1732	3.2342	3.2952	3.3563	3.4173	3.4783	3.5393	3.6004	50
60	3.6614	3.7224	3.7834	3.8444	3.9055	3.9665	4.0275	4.0885	4.1496	4.2106	60
70	4.2716	4.3326	4.3937	4.4547	4.5157	4.5767	4.6377	4.6988	4.7598	4.8208	70
80	4.8818	4.9429	5.0039	5.0649	5.1259	5.1870	5.2480	5.3090	5.3700	5.4310	80
90	5.4921	5.5531	5.6141	5.6751	5.7362	5.7972	5.8582	5.9192	5.9803	6.0413	90
100	6.1023	6.1633	6.2243	6.2854	6.3464	6.4074	6.4684	6.5295	6.5905	6.6515	100

A—4 CONVERSION TABLE

VOLUME

GALLONS (U. S.) TO LITERS

U.S. gal.	0	1	2	3	4	5	6	7	8	9	U.S. gal.
	liters	liters	liters	liters	liters	liters	liters	liters	liters	liters	
—		3.7854	7.5709	11.3563	15.1417	18.9271	22.7126	26.4980	30.2834	34.0633	—
10	37.8543	41.6397	45.4251	49.2105	52.9960	56.7814	60.5668	64.3523	68.1377	71.9231	10
20	75.7085	79.4940	83.2794	87.0648	90.8502	94.6357	98.4211	102.2065	105.9920	109.7774	20
30	113.5629	117.3482	121.1337	124.9191	128.7045	132.4901	136.2754	140.0608	143.8462	147.6316	30
40	151.4171	155.2025	158.9879	162.7734	166.5588	170.3442	174.1296	177.9151	181.7005	185.4859	40
50	189.2713	193.0568	196.8422	200.6276	204.4131	208.1985	211.9839	215.7693	219.5548	223.3402	50
60	227.1256	230.9110	234.6965	238.4819	242.2673	246.0527	249.8382	253.6236	257.4090	261.1945	60
70	264.9799	268.7653	272.5507	276.3362	280.1216	283.9070	287.6924	291.4779	295.2633	299.0487	70
80	302.8342	306.6196	310.4050	314.1904	317.9759	321.7613	325.5467	329.3321	333.1176	336.9030	80
90	340.6884	344.4738	348.2593	352.0447	355.8301	359.6156	363.4010	367.1864	370.9718	374.7573	90
100	378.5427	382.3281	386.1135	389.8990	393.6844	397.4698	401.2553	405.0407	408.8261	412.6115	100

LITERS TO GALLONS (U.S.)

liters	0	1	2	3	4	5	6	7	8	9	liters
	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	
—		0.2642	0.5283	0.7925	1.0567	1.3209	1.5850	1.8492	2.1134	2.3775	—
10	2.6417	2.9059	3.1701	3.4342	3.6984	3.9626	4.2268	4.4909	4.7551	5.0193	10
20	5.2834	5.5476	5.8118	6.0760	6.3401	6.6043	6.8685	7.1326	7.3968	7.6610	20
30	7.9252	8.1893	8.4535	8.7177	8.9818	9.2460	9.5102	9.7743	10.0385	10.3027	30
40	10.5669	10.8311	11.0952	11.3594	11.6236	11.8877	12.1519	12.4161	12.6803	12.9444	40
50	13.2086	13.4728	13.7369	14.0011	14.2653	14.5295	14.7936	15.0578	15.3220	15.5861	50
60	15.8503	16.1145	16.3787	16.6428	16.9070	17.1711	17.4354	17.6995	17.9637	18.2279	60
70	18.4920	18.7562	19.0204	19.2846	19.5487	19.8129	20.0771	20.3412	20.6054	20.8696	70
80	21.1338	21.3979	21.6621	21.9263	22.1904	22.4546	22.7188	22.9830	23.2471	23.5113	80
90	23.7755	24.0397	24.3038	24.5680	24.8322	25.0963	25.3605	25.6247	25.8889	26.1530	90
100	26.4172	26.6814	26.9455	27.2097	27.4739	27.7381	28.0022	28.2664	28.5306	28.7947	100

GALLONS (IMP.) TO LITERS

Imp gal.	0	1	2	3	4	5	6	7	8	9	Imp gal.
	liters	liters	liters	liters	liters	liters	liters	liters	liters	liters	
—		4.5459	9.0918	13.6377	18.1836	22.7295	27.2754	31.8213	36.3672	40.9131	—
10	45.4590	50.0049	54.5508	59.0967	63.6426	68.1885	72.7344	77.2803	81.8262	86.3721	10
20	90.9180	95.4639	100.0098	104.5557	109.1016	113.6475	118.1934	122.7393	127.2852	131.8311	20
30	136.3770	140.9229	145.4688	150.0147	154.5606	159.1065	163.6524	168.1983	172.7442	177.2901	30
40	181.8360	186.3819	190.9278	195.4737	200.0196	204.5655	209.1114	213.6573	218.2032	222.7491	40
50	227.2950	231.8409	236.3868	240.9327	245.4786	250.0245	254.5704	259.1163	263.6622	268.2081	50
60	272.7540	277.2999	281.8458	286.3917	290.9376	295.4835	300.0294	304.5753	309.1212	313.6671	60
70	318.2130	322.7589	327.3048	331.8507	336.8966	340.9425	345.4884	350.0343	354.5802	359.1261	70
80	363.6720	368.2179	372.7638	377.3097	381.8556	386.4015	390.9474	395.4933	400.0392	404.5851	80
90	409.1310	413.6769	418.2228	422.7687	427.3146	431.8605	436.4064	440.9523	445.4982	450.0441	90
100	454.5900	459.1359	463.6818	468.2277	472.7736	477.3195	481.8654	486.4113	490.9572	495.5031	100

LITERS TO GALLONS (IMP.)

liters	0	1	2	3	4	5	6	7	8	9	liter
	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	
—		0.2200	0.4400	0.6599	0.8799	1.0999	1.3199	1.5399	1.7598	1.9798	—
10	2.1998	2.4198	2.6398	2.8597	3.0797	3.2997	3.5197	3.7397	3.9596	4.1796	10
20	4.3996	4.6196	4.8396	5.0595	5.2795	5.4995	5.7195	5.9395	6.1594	6.3794	20
30	6.5994	6.8194	7.0394	7.2593	7.4793	7.6993	7.9193	8.1393	8.3592	8.5792	30
40	8.7992	9.0192	9.2392	9.4591	9.6791	9.8991	10.1191	10.3391	10.5590	10.7790	40
50	10.9990	11.2190	11.4390	11.6590	11.8789	12.0989	12.3189	12.5389	12.7588	12.9788	50
60	13.1988	13.4188	13.6388	13.8587	14.0787	14.2987	14.5187	14.7387	14.9586	15.1786	60
70	15.3986	15.6186	15.8386	16.0585	16.2785	16.4985	16.7185	16.9385	17.1584	17.3784	70
80	17.5984	17.8184	18.0384	18.2583	18.4783	18.6983	18.9183	19.1383	19.3582	19.5782	80
90	19.7982	20.0182	20.2382	20.4581	20.6781	20.8981	21.1181	21.3381	21.5580	21.7780	90
100	21.9980	22.2180	22.4380	22.6579	22.8779	23.0979	23.3179	23.5379	23.7578	23.9778	100

MASS

POUNDS TO KILOGRAMS

lbs.	0	1	2	3	4	5	6	7	8	9	lbs.
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—		0.454	0.907	1.361	1.814	2.268	2.722	3.175	3.629	4.082	—
10	4.536	4.990	5.443	5.897	6.350	6.804	7.257	7.711	8.165	8.618	10
20	9.072	9.525	9.979	10.433	10.886	11.340	11.793	12.247	12.701	13.154	20
30	13.608	14.061	14.515	14.969	15.422	15.876	16.329	16.783	17.237	17.690	30
40	18.144	18.597	19.051	19.504	19.958	20.412	20.865	21.319	21.772	22.226	40
50	22.680	23.133	23.587	24.040	24.494	24.948	25.401	25.855	26.308	26.762	50
60	27.216	27.669	28.123	28.576	29.030	29.484	29.937	30.391	30.844	31.298	60
70	31.751	32.205	32.659	33.112	33.566	34.019	34.473	34.927	35.380	35.834	70
80	36.287	36.741	37.195	37.648	38.102	38.555	39.009	39.463	39.916	40.370	80
90	40.823	41.277	41.731	42.184	42.638	43.091	43.545	43.998	44.452	44.906	90
100	45.359	45.813	46.266	46.720	47.174	47.627	47.081	48.534	48.988	49.442	100

KILOGRAMS TO POUNDS

kg	0	1	2	3	4	5	6	7	8	9	kg
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
—		2.205	4.409	6.614	8.818	11.023	13.228	15.432	17.637	19.842	—
10	22.046	24.251	26.455	28.660	30.865	33.069	35.274	37.479	39.683	41.888	10
20	44.092	46.297	48.502	50.706	52.911	55.116	57.320	59.525	61.729	63.934	20
30	66.139	68.343	70.548	72.753	74.957	77.162	79.366	81.571	83.776	85.980	30
40	88.185	90.390	92.594	94.799	97.003	99.208	101.413	103.617	105.822	108.026	40
50	110.231	112.436	114.640	116.845	119.050	121.254	123.459	125.633	127.868	130.073	50
60	132.277	134.482	136.687	138.891	141.096	143.300	145.505	147.710	149.914	152.119	60
70	154.324	156.528	158.732	160.937	163.142	165.347	167.551	169.756	171.961	174.165	70
80	176.370	178.574	180.780	182.984	185.188	187.393	189.597	191.802	194.007	196.211	80
90	198.416	200.621	202.825	205.030	207.234	209.439	211.644	213.848	216.053	218.258	90
100	220.462	222.667	224.871	227.076	229.281	231.485	233.690	235.895	238.099	240.304	100

KILOGRAMS TO NEWTONS

kg	0	1	2	3	4	5	6	7	8	9	kg
	N	N	N	N	N	N	N	N	N	N	
—	—	9.81	19.61	29.42	39.23	49.03	58.84	68.65	78.45	88.26	—
10	98.07	107.87	117.68	127.49	137.29	147.10	156.91	166.71	176.52	186.33	10
20	196.13	205.94	215.75	225.55	235.36	245.17	254.97	264.78	274.59	284.39	20
30	294.20	304.01	313.81	323.62	333.43	343.23	353.04	362.85	372.65	382.46	30
40	392.27	402.07	411.88	421.69	431.49	441.30	451.11	460.91	470.72	480.53	40
50	490.33	500.14	509.95	519.75	529.56	539.37	549.17	558.98	568.79	578.59	50
60	558.40	598.21	608.01	617.82	627.63	637.43	647.24	657.05	666.85	676.66	60
70	686.47	696.27	706.08	715.89	725.69	735.50	745.31	755.11	764.92	774.73	70
80	784.53	794.34	804.15	813.95	823.76	833.57	843.37	853.18	862.99	872.79	80
90	882.60	892.41	902.21	912.02	921.83	931.63	941.44	951.25	961.05	970.86	90
100	980.67	990.47	1000.28	1010.08	1019.89	1029.70	1039.50	1049.31	1059.12	1068.92	100

NEWTONS TO KILOGRAMS

N	0	10	20	30	40	50	60	70	80	90	N
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
100	10.197	11.217	12.237	13.256	14.276	15.296	16.316	17.335	18.355	19.375	100
200	20.394	21.414	22.434	23.453	24.473	25.493	26.513	27.532	28.552	29.572	200
300	30.592	31.611	32.631	33.651	34.670	35.690	36.710	37.730	38.749	39.769	300
400	40.789	41.809	42.828	43.848	44.868	45.887	46.907	47.927	48.947	49.966	400
500	50.986	52.006	53.025	54.045	55.065	56.085	57.104	58.124	59.144	60.163	500
600	61.183	62.203	63.223	64.242	65.262	66.282	67.302	68.321	69.341	70.361	600
700	71.380	72.400	73.420	74.440	75.459	76.479	77.499	78.518	79.538	80.558	700
800	81.578	82.597	83.617	84.637	85.656	86.676	87.696	88.716	89.735	90.755	800
900	91.775	92.795	93.814	94.834	95.854	96.873	97.893	98.913	99.933	100.952	900
1000	101.972	102.992	104.011	105.031	106.051	107.071	108.090	109.110	110.130	111.149	1000

A–6 CONVERSION TABLE

PRESSURE

POUNDS PER SQUARE INCH TO KILOGRAMS PER SQUARE CENTIMETER

lb/in²	0	1	2	3	4	5	6	7	8	9	lb/in²
(psi)	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	(psi)
—		0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5625	0.6328	—
10	0.7031	0.7734	0.8437	0.9140	0.9843	1.0546	1.1249	1.1952	1.2655	1.3358	10
20	1.4061	1.4764	1.5468	1.6171	1.6874	1.7577	1.8280	1.8983	1.9686	2.0389	20
30	2.1092	2.1795	2.2498	2.3201	2.3904	2.4607	2.5311	2.6014	2.6717	2.7420	30
40	2.8123	2.8826	2.9529	3.0232	3.0935	3.1638	3.2341	3.3044	3.3747	3.4450	40
50	3.5154	3.5857	3.6560	3.7263	3.7966	3.8669	3.9372	4.0075	4.0778	4.1481	50
60	4.2184	4.2887	4.3590	4.4293	4.4996	4.5700	4.6403	4.7106	4.7809	4.8512	60
70	4.9215	4.9918	5.0621	5.1324	5.2027	5.2730	5.3433	5.4136	5.4839	5.5543	70
80	5.6246	5.6947	5.7652	5.8355	5.9058	5.9761	6.0464	6.1167	6.1870	6.2573	80
90	6.3276	6.3979	6.4682	6.5386	6.6089	6.6792	6.7495	6.8198	6.8901	6.9604	90
100	7.0307	7.1010	7.1713	7.2416	7.3119	7.3822	7.4525	7.5228	7.5932	7.6635	100

KILOGRAMS PER SQUARE CENTIMETER TO POUNDS PER SQUARE INCH

kg/cm²	0	1	2	3	4	5	6	7	8	9	kg/cm²
	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	lb/in²(psi)	
—		14.22	28.45	42.67	56.89	71.12	85.34	99.56	113.78	128.01	—
10	142.23	156.45	170.68	184.90	199.12	213.35	227.57	241.79	256.01	270.24	10
20	284.46	298.68	312.91	327.13	341.35	355.58	369.80	384.02	398.24	412.47	20
30	426.69	440.91	455.14	469.36	483.58	497.81	512.03	526.25	540.47	554.70	30
40	568.92	583.14	597.37	611.59	625.81	640.04	654.26	668.48	682.70	696.93	40
50	711.16	725.37	739.60	753.82	768.04	782.27	795.49	810.71	824.93	839.16	50
60	853.38	867.60	881.83	896.05	910.27	924.50	938.72	952.94	967.16	981.39	60
70	995.61	1009.83	1024.06	1038.28	1052.50	1066.73	1080.95	1095.17	1109.39	1123.62	70
80	1137.84	1152.06	1166.27	1180.51	1194.73	1208.96	1223.18	1237.40	1251.62	1265.85	80
90	1280.07	1294.20	1308.52	1322.74	1336.96	1351.19	1365.41	1379.63	1393.85	1408.08	90
100	1422.30	1436.52	1450.75	1464.97	1479.19	1493.42	1507.64	1521.86	1536.08	1550.31	100

KILOGRAMS PER SQUARE CENTIMETER TO KILO PASCAL

kg/cm²	0	1	2	3	4	5	6	7	8	9	kg/cm²
	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	
—	—	98.1	196.1	294.2	392.3	490.3	588.4	686.5	784.5	882.6	—
10	980.7	1078.7	1176.8	1274.9	1372.9	1471.0	1569.1	1667.1	1765.2	1863.3	10
20	1961.3	2059.4	2157.5	2255.5	2353.6	2451.7	2549.7	2647.8	2745.9	2843.9	20
30	2942.0	3040.1	3138.1	3236.2	3334.3	3432.3	3530.4	3628.5	3726.5	3824.6	30
40	3922.7	4020.7	4118.8	4216.9	4314.9	4413.0	4511.1	4609.1	4707.2	4805.3	40
50	4903.3	5001.4	5099.5	5197.5	5295.6	5393.7	5491.7	5589.8	5687.9	5785.9	50
60	5584.0	5982.1	6080.1	6178.2	6276.3	6374.3	6472.4	6570.5	6668.5	6766.6	60
70	6864.7	6962.7	7060.8	7158.9	7256.9	7355.0	7453.1	7551.1	7649.2	7747.3	70
80	7845.3	7943.4	8041.5	8139.5	8237.6	8335.7	8433.7	8531.8	8629.9	8727.9	80
90	8826.0	8924.1	9022.1	9120.2	9218.3	9316.3	9414.4	9512.5	9610.5	9708.6	90
100	9806.7	9904.7	10002.8	10100.8	10198.9	10297.0	10395.0	10493.1	10591.2	10689.2	100

KILO PASCAL TO KILOGRAMS PER SQUARE CENTIMETER

KPa	0	100	200	300	400	500	600	700	800	900	KPa
	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
1000	10.197	11.217	12.237	13.256	14.276	15.296	16.316	17.335	18.355	19.375	1000
2000	20.394	21.414	22.434	23.453	24.473	25.493	26.513	27.532	28.552	29.572	2000
3000	30.592	31.611	32.631	33.651	34.670	35.690	36.710	37.730	38.749	39.769	3000
4000	40.789	41.809	42.828	43.848	44.868	45.887	46.907	47.927	48.947	49.966	4000
5000	50.986	52.006	53.025	54.045	55.065	56.085	57.104	58.124	59.144	60.163	5000
6000	61.183	62.203	63.223	64.242	65.262	66.282	67.302	68.321	69.341	70.361	6000
7000	71.380	72.400	73.420	74.440	75.459	76.479	77.499	78.518	79.538	80.558	7000
8000	81.578	82.597	83.617	84.637	85.656	86.676	87.696	88.716	89.735	90.755	8000
9000	91.775	92.794	93.814	94.834	95.854	96.873	97.893	98.913	99.933	100.952	9000
10000	101.972	102.992	104.011	105.031	106.051	107.071	108.090	109.110	110.130	111.149	10000

TORQUE

FOOT POUNDS TO KILOGRAMMETERS

ft. lbs.	0	1	2	3	4	5	6	7	8	9	ft. lbs.
	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	
—		0.138	0.277	0.415	0.553	0.691	0.830	0.968	1.106	1.244	—
10	1.383	1.521	1.659	1.797	1.936	2.074	2.212	2.350	2.489	2.627	10
20	2.765	2.903	3.042	3.180	3.318	3.456	3.595	3.733	3.871	4.009	20
30	4.148	4.286	4.424	4.562	4.700	4.839	4.977	5.115	5.253	5.392	30
40	5.530	5.668	5.807	5.945	6.083	6.221	6.360	6.498	6.636	6.774	40
50	6.913	7.051	7.189	7.328	7.466	7.604	7.742	7.881	8.019	8.157	50
60	8.295	8.434	8.572	8.710	8.848	8.987	9.125	9.263	9.401	9.540	60
70	9.678	9.816	9.954	10.093	10.231	10.369	10.507	10.646	10.784	10.922	70
80	11.060	11.199	11.337	11.475	11.613	11.752	11.890	12.028	12.166	12.305	80
90	12.442	12.581	12.719	12.858	12.996	13.134	13.272	13.410	13.549	13.687	90
100	13.826	13.964	14.102	14.240	14.379	14.517	14.655	14.793	14.932	15.070	100

KILOGRAMMETERS TO FOOT POUNDS

kg-m	0	1	2	3	4	5	6	7	8	9	kg-m
	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	
—		7.23	14.47	21.70	28.93	36.17	43.40	50.63	57.86	65.10	—
10	72.33	79.56	86.80	94.03	101.26	108.50	115.73	122.96	130.19	137.43	10
20	144.66	151.89	159.13	166.36	173.59	180.83	188.06	195.29	202.52	209.76	20
30	217.00	224.22	231.46	238.69	245.92	253.16	260.39	267.62	274.85	282.09	30
40	289.32	296.55	303.79	311.02	318.25	325.49	332.72	339.95	347.18	354.42	40
50	361.65	368.88	376.12	383.35	390.58	397.82	405.05	412.28	419.51	426.75	50
60	433.98	441.21	448.45	455.68	462.91	470.15	477.38	484.61	491.84	499.08	60
70	506.31	513.54	520.78	528.01	535.24	542.48	549.71	556.94	564.17	571.41	70
80	578.64	585.87	593.11	600.34	607.57	614.81	622.04	629.27	636.50	643.74	80
90	650.97	658.20	665.44	672.67	679.90	687.14	694.37	701.60	708.83	716.07	90
100	723.30	730.53	737.77	745.00	752.23	759.47	766.70	773.93	781.16	788.40	100

KILOGRAMMETERS TO NEWTONMETERS

kg-m	0	1	2	3	4	5	6	7	8	9	kg-m
	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	
—	—	9.81	19.61	29.42	39.23	49.03	58.84	68.65	78.45	88.26	—
10	98.07	107.87	117.68	127.49	137.29	147.10	156.91	166.71	176.52	186.33	10
20	196.13	205.94	215.75	225.55	235.36	245.17	254.97	264.78	274.59	284.39	20
30	294.20	304.01	313.81	323.62	333.43	343.23	353.04	362.85	372.65	382.46	30
40	392.27	402.07	411.88	421.69	431.49	441.30	451.11	460.91	470.72	480.53	40
50	490.33	500.14	509.95	519.75	529.56	539.37	549.17	558.98	568.79	578.59	50
60	588.40	598.21	608.01	617.82	627.63	637.43	647.24	657.05	666.85	676.66	60
70	686.47	696.27	706.08	715.89	725.69	735.50	745.31	755.11	764.92	774.73	70
80	784.53	794.34	804.15	813.95	823.76	833.57	843.37	853.18	862.99	872.79	80
90	882.60	892.41	902.21	912.02	921.83	931.63	941.44	951.25	961.05	970.86	90
100	980.67	990.47	1000.28	1010.08	1019.89	1029.70	1039.50	1049.31	1059.12	1068.92	100

NEWTONMETERS TO KILOGRAMMETERS

N-m	0	10	20	30	40	50	60	70	80	90	N-m
	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
100	10.197	11.217	12.236	13.256	14.276	15.296	16.315	17.335	18.355	19.374	100
200	20.394	21.414	22.433	23.453	24.473	25.493	26.512	27.532	28.552	29.571	200
300	30.591	31.611	32.630	33.650	34.670	35.690	36.710	37.729	38.749	39.768	300
400	40.789	41.808	42.827	43.847	44.867	45.887	46.906	47.926	48.946	49.965	400
500	50.986	52.005	53.024	54.044	55.064	56.084	57.103	58.123	59.143	60.162	500
600	61.183	62.202	63.221	64.241	65.261	66.281	67.300	68.320	69.340	70.359	600
700	71.380	72.399	73.418	74.438	75.458	76.478	77.497	78.517	79.537	80.556	700
800	81.577	82.596	83.615	84.635	85.655	86.675	87.694	88.714	89.734	90.753	800
900	91.774	92.793	93.812	94.832	95.852	96.872	97.891	98.911	99.931	100.950	900
1000	101.972	102.990	104.009	105.029	106.049	107.069	108.088	109.108	110.128	111.147	1000

TEMPERATURE

FAHRENHEIT TO CENTIGRADE

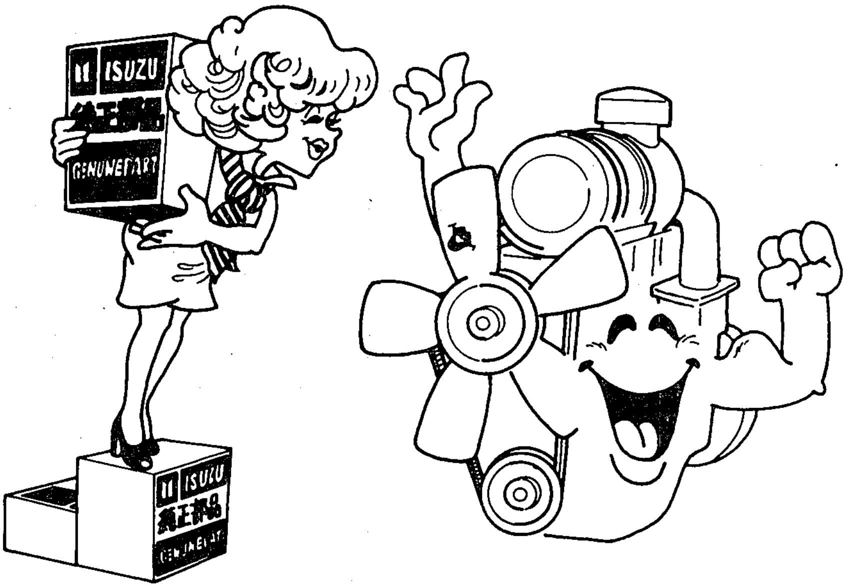
°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
-60	-51.1	-2	-18.9	56	13.3	114	45.6	172	77.8	230	110.0	288	142.2	346	174.4
-58	-50	0	-17.8	58	14.4	116	46.7	174	78.9	232	111.1	290	143.3	348	175.6
-56	-48.9	2	-16.7	60	15.6	118	47.8	176	80.0	234	112.2	292	144.4	350	176.7
-54	-47.8	4	-15.6	62	16.7	120	48.9	178	81.1	236	113.3	294	145.6	352	177.8
-52	-46.7	6	-14.4	64	17.8	122	50.0	180	82.2	238	114.4	296	146.7	354	178.9
-50	-45.6	8	-13.3	66	18.9	124	51.1	182	83.3	240	115.6	298	147.8	356	180.0
-48	-44.4	10	-12.2	68	20.0	126	52.2	184	84.4	242	116.7	300	148.9	358	181.1
-46	-43.3	12	-11.1	70	21.1	128	53.3	186	85.6	244	117.8	302	150.0	360	182.2
-44	-42.2	14	-10.0	72	22.2	130	54.4	188	86.7	246	118.9	304	151.1	362	183.3
-42	-41.1	16	-8.9	74	23.3	132	55.6	190	87.8	248	120.0	306	152.2	364	184.4
-40	-40.0	18	-7.8	76	24.9	134	56.7	192	88.9	250	121.1	308	153.3	366	185.6
-38	-38.9	20	-6.7	78	25.6	136	57.8	194	90.0	252	122.2	310	154.4	368	186.7
-36	-37.8	22	-5.6	80	26.7	138	58.9	196	91.1	254	123.3	312	155.6	370	187.8
-34	-36.7	24	-4.4	82	27.8	140	60.0	198	92.2	256	124.4	314	156.7	372	188.9
-32	-35.6	26	-3.3	84	28.9	142	61.1	200	93.3	258	125.6	316	157.8	374	190.0
-30	-34.4	28	-2.2	86	30.0	144	62.2	202	94.4	260	126.7	318	158.9	376	191.1
-28	-33.3	30	-1.1	88	31.1	146	63.3	204	95.6	262	127.8	320	160.0	378	192.2
-26	-32.2	32	-0	90	32.2	148	64.4	206	96.7	264	128.9	322	161.1	380	193.3
-24	-31.1	34	1.1	92	33.3	150	65.6	208	97.8	266	130.0	324	162.2	382	194.4
-22	-30.0	36	2.2	94	34.4	152	66.7	210	98.9	268	131.1	326	163.3	384	195.6
-20	-28.9	38	3.3	96	35.6	154	67.8	212	100.0	270	132.2	328	164.4	386	196.7
-18	-27.8	40	4.4	98	36.7	156	68.9	214	101.1	272	133.3	330	165.6	388	197.8
-16	-26.7	42	5.6	100	37.8	158	70.0	216	102.2	274	134.4	332	166.7	390	198.9
-14	-25.6	44	6.7	102	38.9	160	71.1	218	103.3	276	135.6	334	167.8	392	200.0
-12	-24.4	46	7.8	104	40.0	162	72.2	220	104.4	278	136.7	336	168.9	400	204.4
-10	-23.3	48	8.9	106	41.1	164	73.3	222	105.6	280	137.8	338	170.0	410	210.0
-8	-22.2	50	10.0	108	42.2	166	74.4	224	106.7	282	138.9	340	171.1	420	215.6
-6	-21.1	52	11.1	110	43.3	168	75.6	226	107.8	284	140.0	342	172.2	430	221.1
-4	-20.0	54	12.2	112	44.4	170	76.7	228	108.9	286	141.1	344	173.3	440	226.7

CENTIGRADE TO FAHRENHEIT

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-50	-58.0	-18	- 0.4	14	57.2	46	114.8	78	172.4	110	230.0	142	287.6	174	345.2
-49	-56.2	-17	1.4	15	59.0	47	116.6	79	174.2	111	231.8	143	289.4	175	347.0
-48	-54.4	-16	3.2	16	60.8	48	118.4	80	176.0	112	233.6	144	291.2	176	348.8
-47	-52.6	-15	5.0	17	62.6	49	120.2	81	177.8	113	235.4	145	293.0	177	350.6
-46	-50.8	-14	6.8	18	64.4	50	122.0	82	179.6	114	237.2	146	294.8	178	352.4
-45	-49.0	-13	8.6	19	66.2	51	123.8	83	181.4	115	239.0	147	296.6	179	354.2
-44	-47.2	-12	10.4	20	68.0	52	125.6	84	183.2	116	240.8	148	298.4	180	356.0
-43	-45.4	-11	12.2	21	69.8	53	127.4	85	185.0	117	242.6	149	300.2	181	357.8
-42	-43.6	-10	14.0	22	71.6	54	129.2	86	186.8	118	244.4	150	302.0	182	359.6
-41	-41.8	-9	15.8	23	73.4	55	131.0	87	188.6	119	246.2	151	303.8	183	361.4
-40	-40.0	-8	17.6	24	75.2	56	132.8	88	190.4	120	248.0	152	305.6	184	363.2
-39	-38.2	-7	19.4	25	77.0	57	134.6	89	192.2	121	249.8	153	307.4	185	365.0
-38	-36.4	-6	21.2	26	78.8	58	136.4	90	194.0	122	251.6	154	309.2	186	366.8
-37	-34.6	-5	23.0	27	80.6	59	138.2	91	195.8	123	253.4	155	311.0	187	368.6
-36	-32.8	-4	24.8	28	82.4	60	140.0	92	197.6	124	255.2	156	312.8	188	370.4
-35	-31.0	-3	26.6	29	84.2	61	141.8	93	199.4	125	257.0	157	314.6	189	372.2
-34	-29.2	-2	28.4	30	86.0	62	143.6	94	201.2	126	258.8	158	316.4	190	374.0
-33	-27.4	-1	30.2	31	87.8	63	145.4	95	203.0	127	260.6	159	318.2	191	375.8
-32	-25.6	0	32.0	32	89.6	64	147.2	96	204.8	128	262.4	160	320.0	192	377.6
-31	-23.8	1	33.8	33	91.4	65	149.0	97	206.6	129	264.2	161	321.8	193	379.4
-30	-22.0	2	35.6	34	93.2	66	150.8	98	208.4	130	266.0	162	323.6	194	381.2
-29	-20.2	3	37.4	35	95.0	67	152.6	99	210.2	131	267.8	163	325.4	195	383.0
-28	-18.4	4	39.2	36	96.8	68	154.4	100	212.0	132	269.6	164	327.2	196	384.8
-27	-16.6	5	41.0	37	98.6	69	156.2	101	213.8	133	271.4	165	329.0	197	386.6
-26	-14.8	6	42.8	38	100.4	70	158.0	102	215.6	134	273.2	166	330.8	198	388.4
-25	-13.0	7	44.6	39	102.2	71	159.8	103	217.4	135	275.0	167	332.6	199	390.2
-24	-11.2	8	46.4	40	104.0	72	161.6	104	219.2	136	276.8	168	334.4	200	392.0
-23	-9.4	9	48.2	41	105.8	73	163.4	105	221.0	137	278.6	169	336.4	210	410.0
-22	-7.6	10	50.0	42	107.6	74	165.2	106	222.8	138	280.4	170	338.0	220	428.0
-21	-5.8	11	51.8	43	109.4	75	167.0	107	224.6	139	282.2	171	339.8	230	446.0
-20	-4.4	12	53.6	44	111.2	76	168.8	108	226.4	140	284.0	172	341.6	240	464.0
-19	-2.2	13	55.4	45	113.0	77	170.6	109	228.2	141	285.8	173	343.4	250	482.0

MEMO

"QUALITY PARTS YOU CAN TRUST"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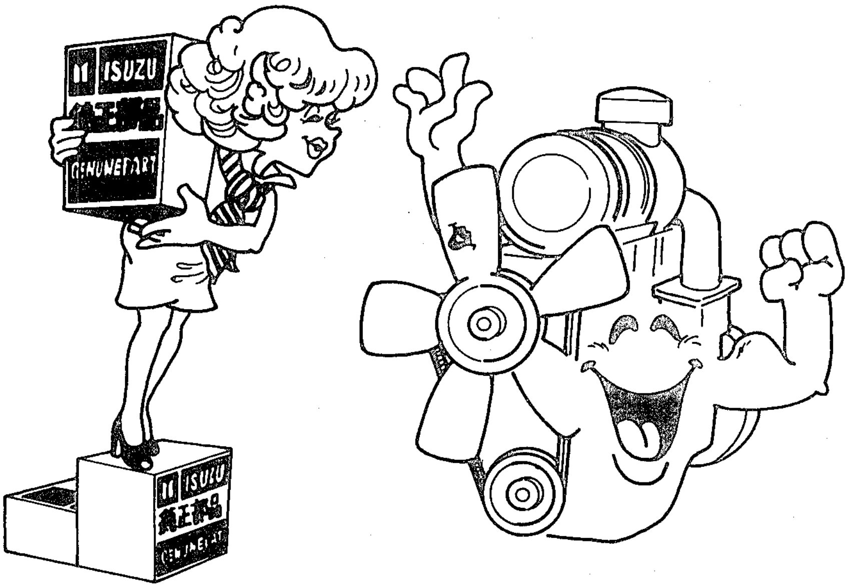
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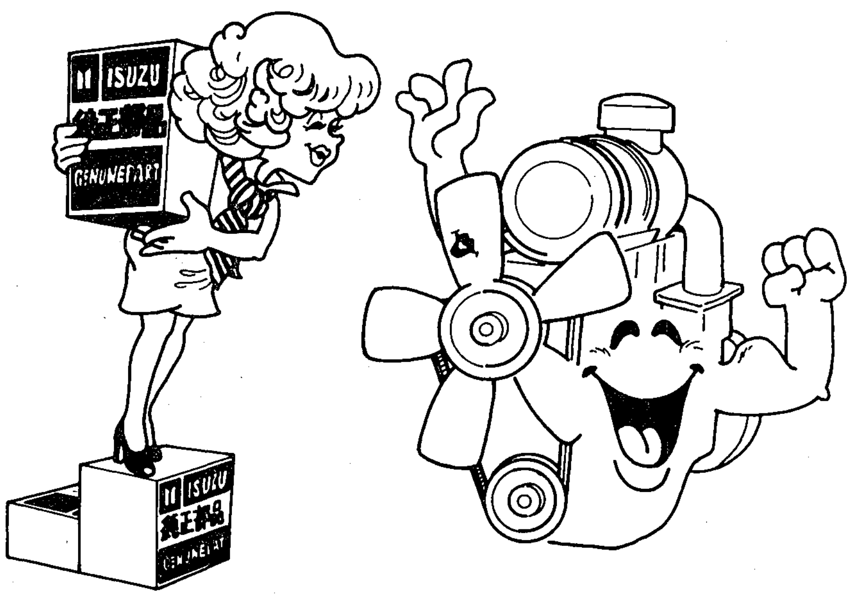
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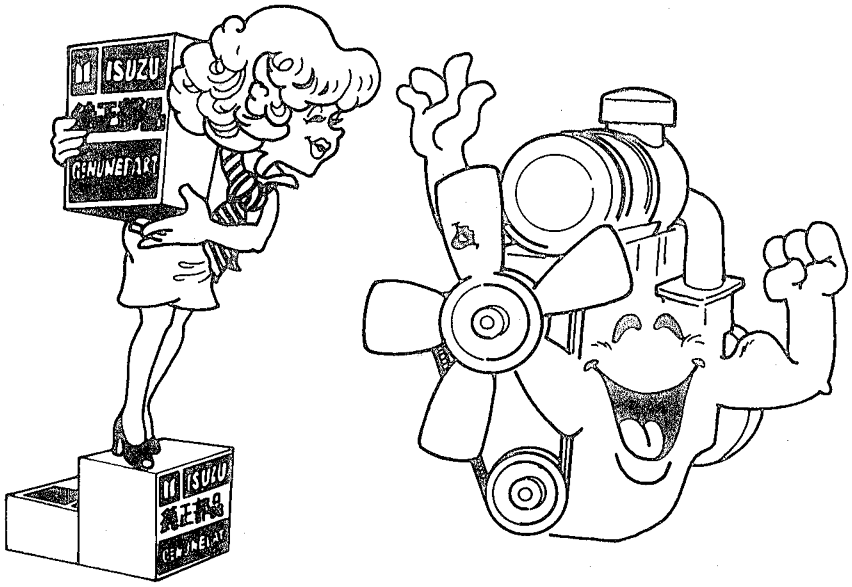
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WORKSHOP MANUAL
INDUSTRIAL DIESEL ENGINE
4JA1, 4JB1, 4JC1
(IDE-2170)

Issued by

ISUZU MOTORS LIMITED

ENGINE SALES ENGINEERING DEPT.

Tokyo, Japan

First edition Oct., 1986 004-07-400K

SHOP MANUAL

model SK60

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○How to Index each Shop Manual Section
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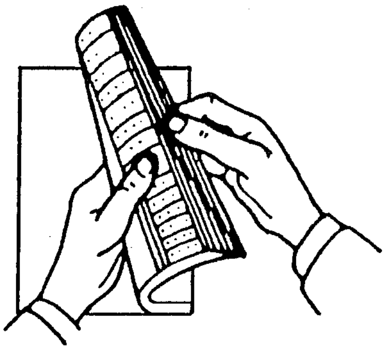

KOBELCO

COMPONENTS

Book code No. S5LE3005E①

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12	HYDRAULIC PUMP	S5120313E 1990-6			
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13	CONTOROL VALVE	S5130082E 1990-10			
	PILOT VALVE (WRIST CONTROL)	S5130450E① 1990-6			
	PILOT VALVE (TH40K)	S5130457E① 1990-6			
	CONTOROL VALVE (SWING)	S5130666E① 1990-6			
	CONTOROL VALVE	S5130702E 1990-6			
14	RELIEF VALVE (PILOT)	S5140461E⑨ 1990-6			
	HOLDING VALVE (BOOM SAFETY)	S5140692E 1990-6			
15	HYDRAULIC MOTOR (SWING)	S5150445E 1990-6			
	HYDRAULIC MOTOR (TRAVEL)	S5150451E 1990-6			
16	SWIVEL JOINT	S5160116E 1990-6			
17	HYDRAULIC CYLINDER (0.7m³H.Sh)	S5170145E 1990-6			
21	REDUCTION UNIT (SWING)	S5210222E 1990-6			
	Applicable Machines	LE-11001~			

BooK code No. S5 12031 3E

KOBELCO

SHOP MANUAL

HYDRAULIC PUMP

12

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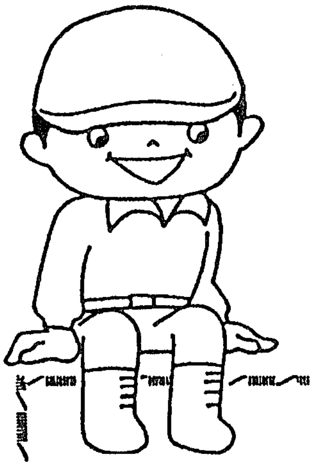


PREFACE

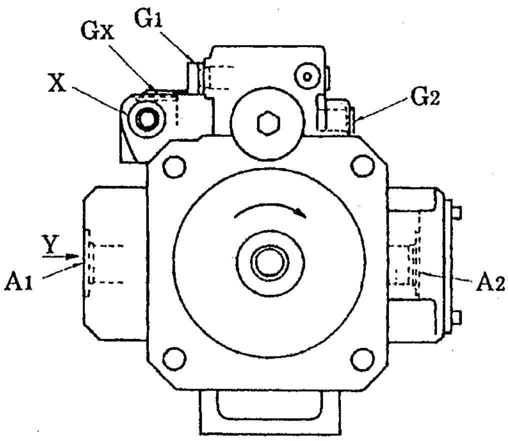
The hydraulic pump sucks hydraulic oil, pressurized it and delivers it to various components. This manual explains a single hydraulic pump. For the functions and performances of the hydraulic pump in the excavator, refer to separate manual.

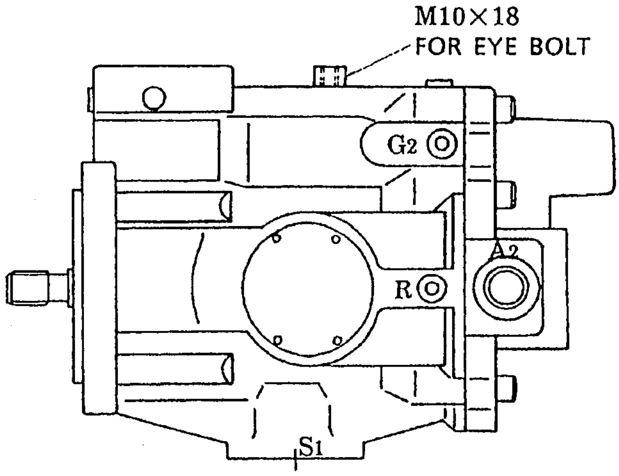
Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

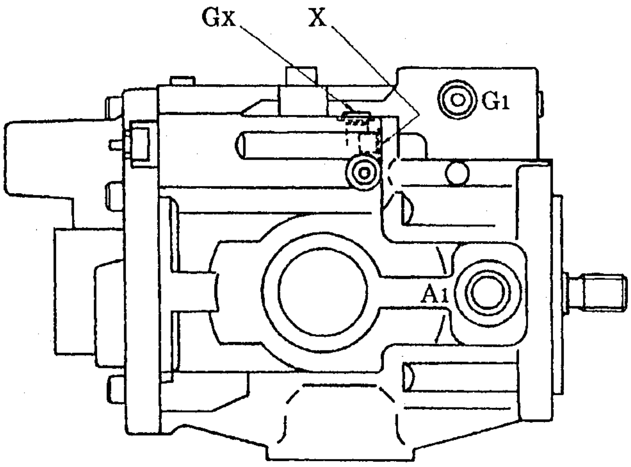
Revision	Date of Issue	Remarks
First edition	June, 1990	S5120313E K

1. SPECIFICATION

1.1 APPEARANCE







VIEW Y

Description of ports

Code	Name of port	Port size
A_1,A_2	Delivery port	G 3/4
S_1	Suction port	SAE 2
X	Pilot port	G 1/4
G_1,G_2,G_X	Gauge port	G 1/4
R	Air venting port	G 1/4

Fig. 1

1.2 PRINCIPAL PARTICULARS

Table 1

Item \ Model		A10VD43SR1RS5-990-0	A10VD43SR1RS5-983-0 (Option)
Displacement capacity	cc/rev (cuin/rev)	37.3 (2.28)×2	←
Rated pressure	kgf/cm^2 (psi)	210 (2990)×2	←
Max. pressure	kgf/cm^2 (psi)	260 (3700)×2	←
Rated revolution	r.p.m	2,200	←
Max. flow	ℓ/min (gal/min)	82 (21.7)×2	←

2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION

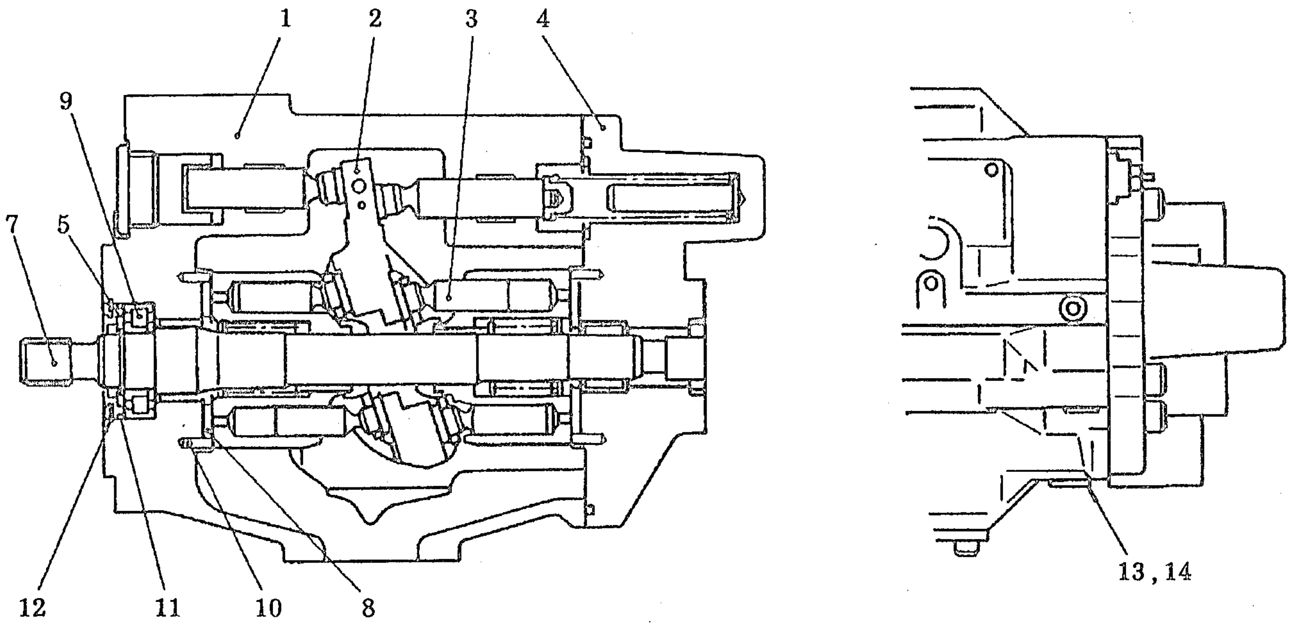
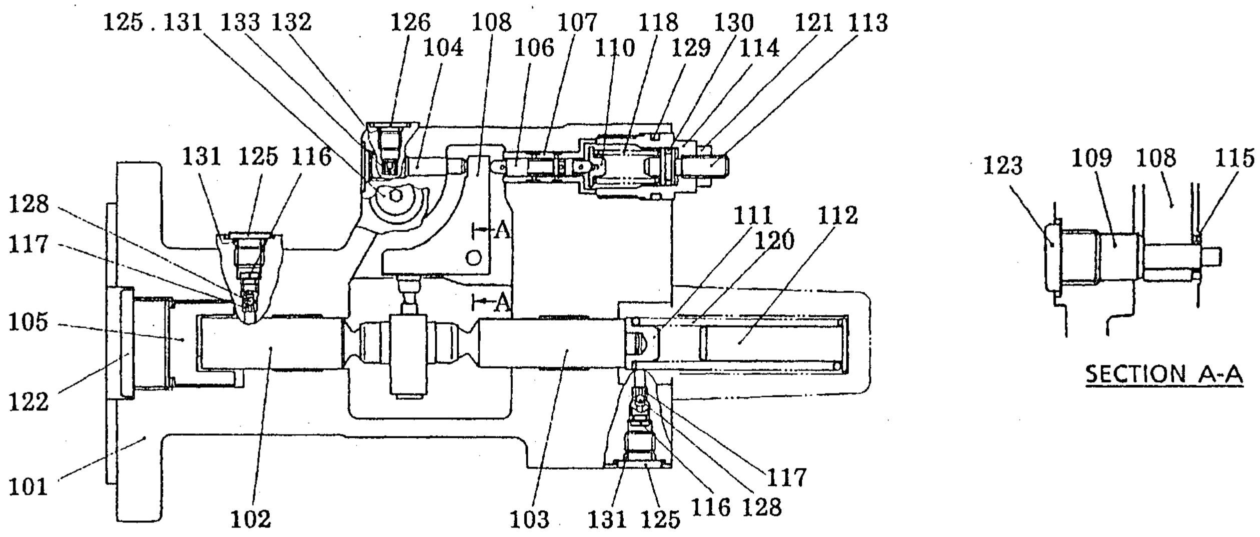


Fig. 2

Table 2

No.	NAME	Q'ty	No.	NAME	Q'ty
1	CONTROL BODY	1	8	CONTROL PLATE	1
2	HANGER	1	9	BEARING	1
3	ROTARY GROUP	2	10	PIN	2
4	COVER	1	11	SHIM	1
5	CASING	1	12	SNAP RING	1
6	–	–	13	PLUG	1
7	SHAFT	1	14	O RING	1

(1) Control body



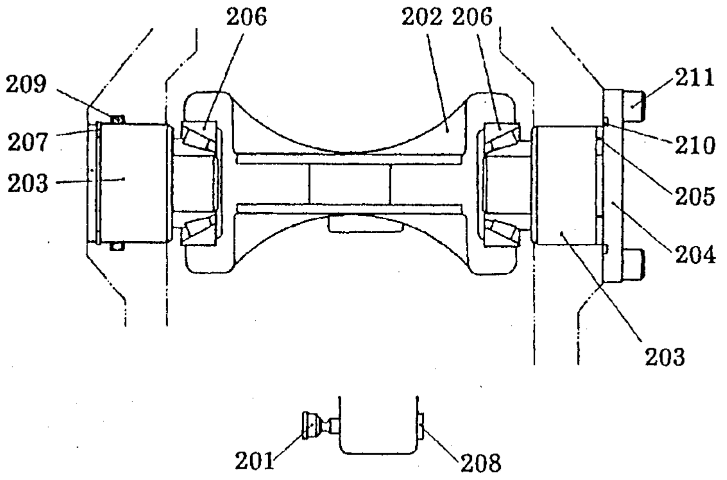
125 . 131
133
132
126
104
108
107
106
110
118
129
130
114
121
113
131
125
116
128
117
105
122
101
102
103
111
120
112
A
A
103
131
125
116
128
117
123
109
108
115
SECTION A-A

Fig. 3

Table 3

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
101	HOUSING	1	111	SPRING SEAT B	1	122	PLUG	1
102	PISTON A	1	112	SPRING SEAT C	1	123	PLUG	1
103	PISTON B	1	113	ADJUST SCREW	1	125	PLUG	3
104	PISTON (FOR SHIFT)	1	114	GUIDE	1	126	PLUG	1
105	DISTANCE PIECE	1	115	SHIM	1	128	BALL	2
106	SPOOL	1	116	VALVE SEAT	2	129	O RING	1
107	BARREL	1	117	GUIDE	2	130	O RING	1
108	ARM	1	118	SPRING	1	131	O RING	3
109	SHAFT	1	120	SPRING (C)	1	132	O RING	1
110	SPRING SEAT A	1	121	NUT	1	133	ORIFICE	1

(2) Hanger



206
202
206
209
207
203
211
210
205
204
203
201
208

Fig. 4

Table 4

No.	NAME	Q'ty
201	PILOT PIN	1
202	HANGER	1
203	SHAFT	2
204	COVER	1
205	SHIM	1
206	BEARING	2
207	SNAP RING	1
208	PLUG	1
209	O RING	1
210	O RING	1
211	SOCKET BOLT	4

(3) Rotary group

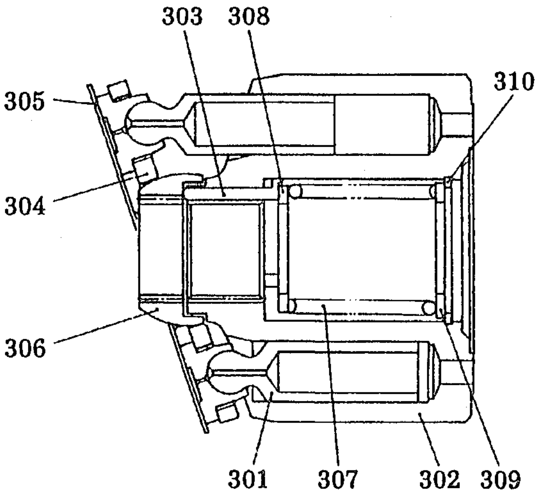

303
308
305
310
304
306
301
307
302
309

Fig. 5

Table 5

No.	NAME	Q'ty
301	PISTON	9
302	CYLINDER BLOCK	1
303	PIN	3
304	RETAINER	1
305	PLATE	1
306	GUIDE	1
307	SPRING	1
308	SPRING SEAT (A)	1
309	SPRING SEAT (B)	1
310	SNAP RING	1

(4) Cover

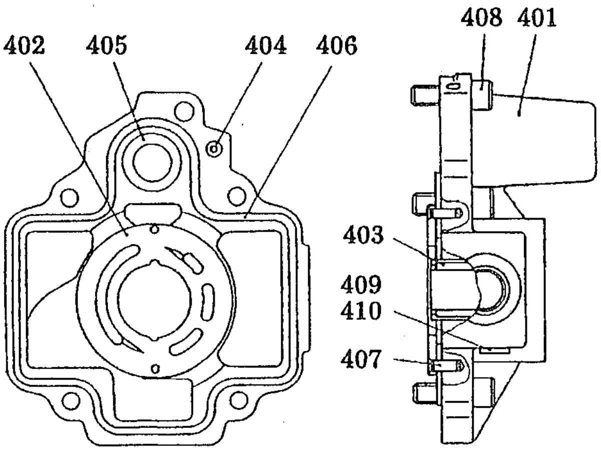

402
405
404
406
408
401
403
409
410
407

Fig. 6

Table 6

No.	NAME	Q'ty
401	COVER	1
402	CONTROL PLATE	1
403	BEARING	1
404	O RING	1
405	O RING	1
406	O RING	1
407	PIN	2
408	SOCKET BOLT	5
409	PLUG	1
410	O RING	1

(5) Case

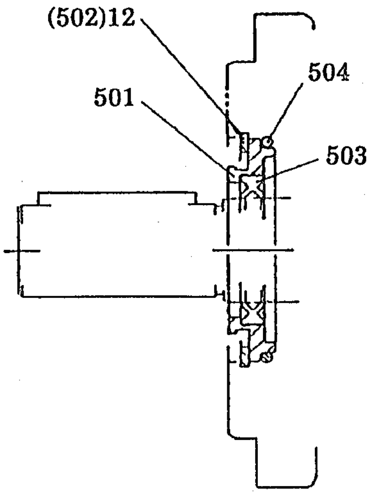

(502)12
504
501
503

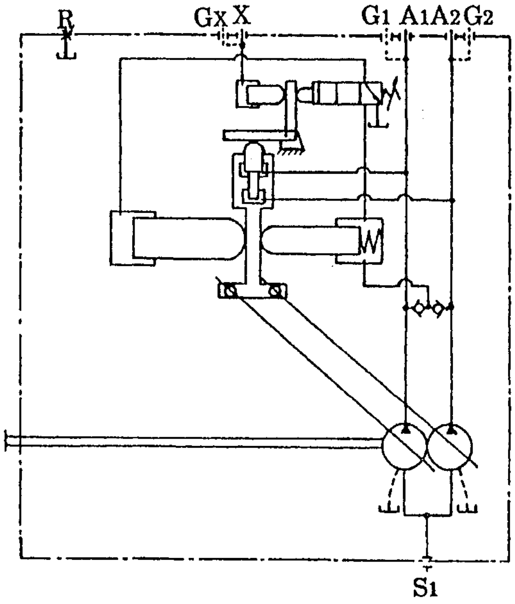
Fig. 7

Table 7

No.	NAME	Q'ty
501	CASE	1
(502)	SNAP RING	1
503	OIL SEAL	1
504	O RING	1

2.2 SUMMARY

The hydraulic pump consists of two swash plate type variable displacement piston pumps of equal capacity arranged on the face and back of a single swash plate, all of which are enclosed in a housing. A double pump which by its compactness looks as if it were a single pump is a feature.
Its single swash plate construction makes the tilting angles of the two pumps equal. The tilting angle of the pumps varies with the total pressure P1+P2 (front : P1, rear : P2), i. e. The pumps are subject to total horsepower control so that the relationship between the delivery pressure and the flow Q is expressed by an equation (P1+P2)×Q=constant.
Further, the pumps are so constructed as to concentrically connect with gear pumps. Gear pumps can be utilized as a control pressure source for the main system or for actuator drive.



A_1, A_2 – Discharge port
S_1 – Suction port
X – Pilot port
G_1, G_2, G_X – Gauge port
R – Venting port

Fig. 8

2.3 CONSTRUCTION AND FUNCTION

2.3.1 FUNCTIONS OF PUMPS

The cylinder block is connected with the drive shaft and makes rotary motion. In this motion, the pistons arranged in the cylinder block make reciprocating motion following the slide plate on the hanger. This brings about variation in the capacity of the cylinder whereby suction and discharge action occurs.
In the suction stroke in which the piston moves from the bottom dead point to the top dead point, oil equal to the displacement of the stroke runs into the cylinder block by way of the port plate.
When the piston makes motion from the top dead point to the bottom dead point, oil is discharged forcibly to the discharge port via the port plate.
Each of the nine pistons completes one process of suction and discharge each time the cylinder block makes one turn, so that suction and discharge are performed continuously as the drive shaft rotates.
Fig. 9 illustrates the front pump section. The rear pump has its top dead point and bottom dead point reversed. As the result, the relation between the suction and discharge strokes is reversed also.
Since the process displacement depends upon the inclination of the slide plate, delivery flow can be varied by changing the inclination of the hanger held to the housing by the bearing.

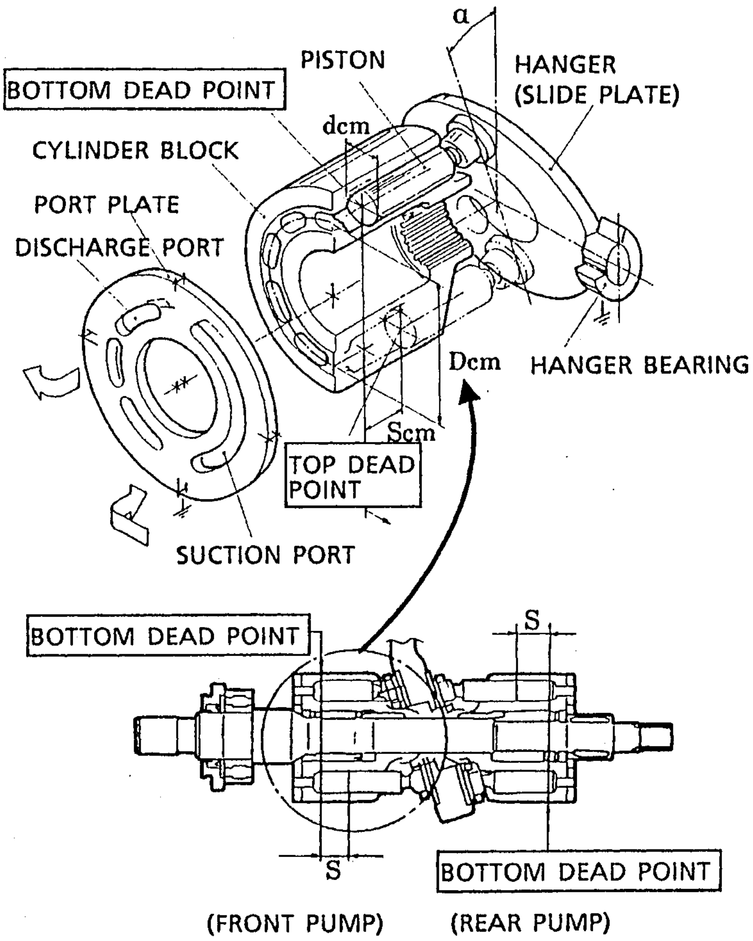


Fig. 9

2.3.2 CONTROL FUNCTION : TOTAL HORSEPOWER CONTROL (WITH MODE SELECT FUNCTION)

Two pumps are full power controlled at the same time. Its principle is described below:

(1) Simultaneous full power control
Pressure P1 and P2 are admitted to the pilot piston in the hanger to make the pressure bearing area (A) of the stepped part and that of the end of the piston equal. Simultaneous control is effected by combining the pressure of the P1 pump and that of the P2 pump.
The pressing force of the piston in the hanger becomes (P1 · A+P2 · A).

(2) Function of increasing the pump flow
The pressing force of the control piston (smaller diameter) toward the maximum tilting side is selected by the high pressure select pressures of the P1 and P2 pumps. The control piston (larger diameter) is connected with the tank by way of the servo spool.
Leftward travel of the control piston (smaller diameter) changes the tilting angle of the swash plate of the pump and increases the pump flow.
The proportion of moments by the hydraulic pressing force on fulcrum C and the spring action are expressed by an equation ; (Pressing force of pilot piston × distance from fulcrum (C)) + (pressing force of shift piston × distance from fulcrum) = servo spool spring action × distance from fulcrum. Tilting is held at a point where moments are balanced.

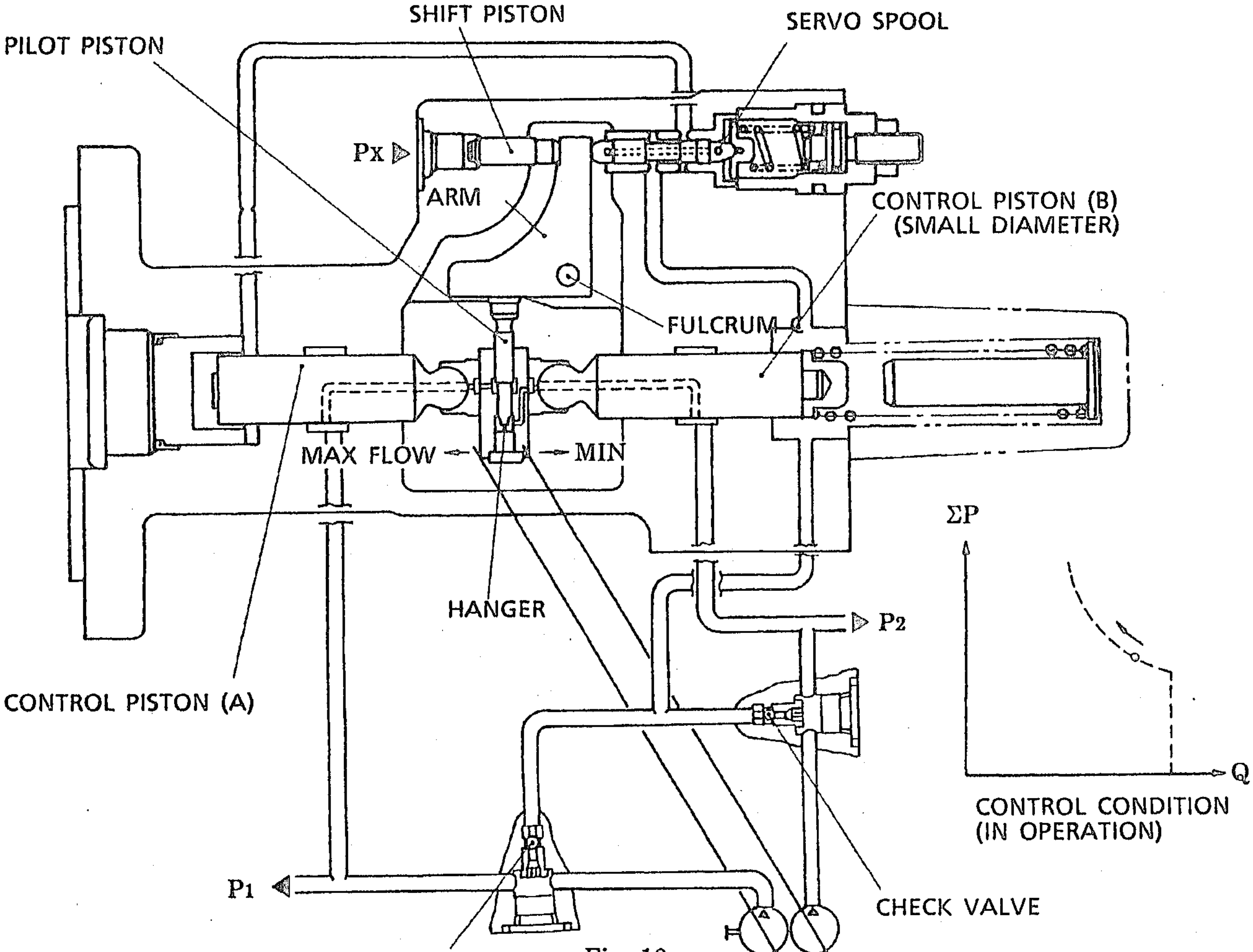


Fig. 10

(3) Power shift control (reduced horsepower control)
If the pressing force of the pilot piston increases as the delivery pressure of either the P1 pump or the P2 pump rises, the moment that turns the arm clockwise on fulcrum C increases. This causes the servo spool spring to move to the right till it is changed over.
If the servo spool is changed over, the discharge pressure of the pumps enters the control piston (large diameter) to shift the hanger piston (larger diameter) to the right.
If the rightward travel of the hanger piston reduces the angle of the swash plate of the pump to reduce the flow of the pump.

(4) Max. flow cut

If pilot pressure enters the PX port of the shift piston, the flow of the pump is reduced the same way as power shift control.

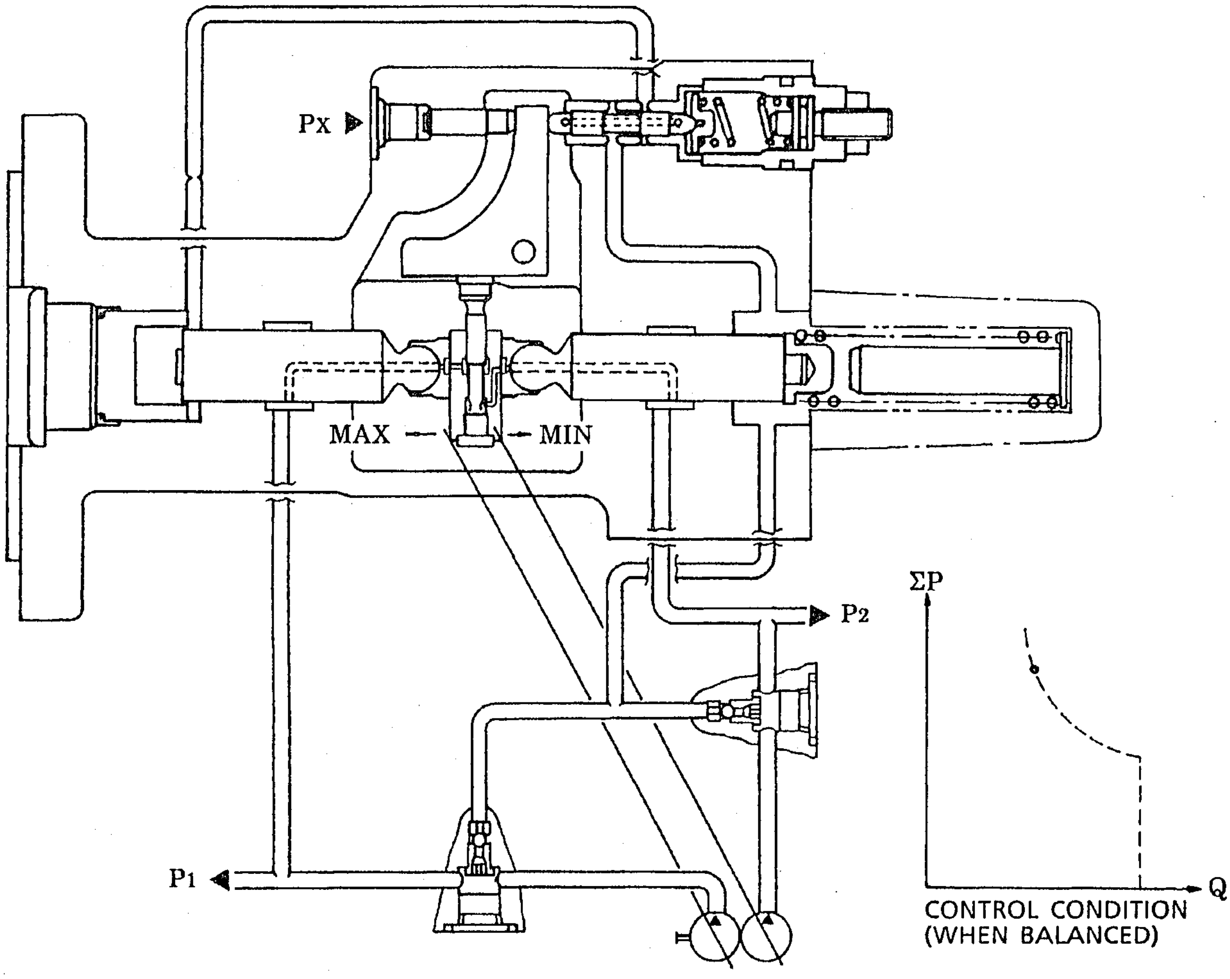


Fig. 11

(5) Principle of total horsepower control

From the equilibrium of moments on the fulcrum of the arm;

$(P_1 \cdot A + P_2 \cdot A) \cdot S + Px \cdot B \cdot a = Fsp \cdot a$ ……… ①

From the relationship between displacement capacity q and stroke S;

$S = k \cdot q$ (k = constant) ……… ②

From ① and ②;

$(P1 + P2) \cdot q = (Fsp - Px \cdot B) \cdot a / (k \cdot A)$ ……… ③

In the meantime, the pump is of single swash plate type, $q = q1 = q2$

Therefore ③ is;

$P_1 \cdot q_1 + P_2 \cdot q_2 = C$

$C = C_1 \cdot Fsp - C_2 \cdot Px$

$(C_1 = a / (C \cdot A),\ C_2 = (a \cdot B) / (k \cdot A))$

This is the torque constant control.

A set torque value can be adjusted arbitrarily by variation of spring force Fsp.

Since it varies in reverse proportion to external pilot pressure Px, mode selection becomes possible by giving a pilot pressure matching a required set torque value.

1) Legend

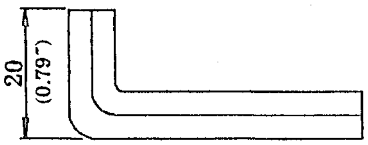
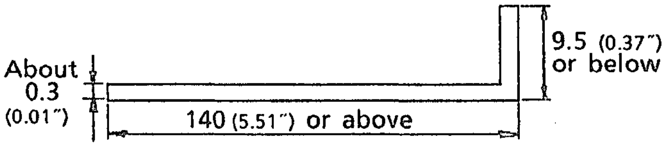
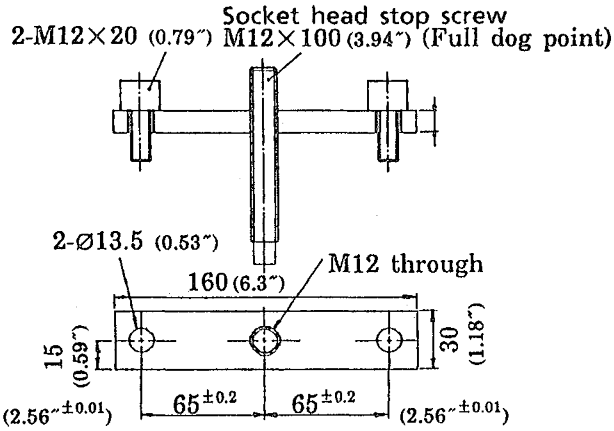
P : Discharge pressure
A : End of pilot piston and annular pressure bearing area
PX : External pilot pressure
B : Pressure bearing area of shift piston
a : Distance between fulcrum and spring force acting point
Fsp : Spring force
S : Distance between fulcrum and hydraulic pressure acting point (stroke at tilting point)
q : Displacement capacity

Affix 1 : Front pump
2 : Rear pump

3. DISASSEMBLY AND ASSEMBLY

3.1 TOOLS

Table 8

NAME	Size (Nominal)	Q'ty
Socket wrench	3, 5, 8, 10, 22	1 each
	6 	1
Spanner	Width across flats: 24mm (0.94in)	1
Plastic hammer	Medium size	1
Snap ring plier	Medium size	1
⊖ driver	Medium size	1
Slide calipers	About 20mm (0.79in)	1
Arm shaft removing jig	M5 bolt ℓ=about 30mm (1.18in)	1
Barrel drawing jig	 About 0.3 (0.01") 9.5 (0.37") or below 140 (5.51") or above	1
Hanger fixing jig	 Socket head stop screw 2-M12×20 (0.79") M12×100 (3.94") (Full dog point) 2-Ø13.5 (0.53") M12 through 160 (6.3") 15 (0.59") 30 (1.18") (2.56"±0.01) 65±0.2 65±0.2 (2.56"±0.01)	1
Grease		A small amount

3.2 DISASSEMBLY

3.2.1 GENERAL PRECAUTIONS

1) Avoid turning adjust screws in any circumstances other than it is necessary. Otherwise, set horsepowers change and have adverse effect on the excavator.
2) After draining out oil from the pump, clean the outside of the pump, place a clean paper, cloth or rubber mattress on a work bench and then perform disassembly and assembly operations. Exercise care so as not to score parts and to prevent intrusion of foreign matter.
3) The front pump and the rear pump are composed of a control section and sets of parts for different sections. Tag or identify parts so front pump parts may not be mixed up with rear pump parts.

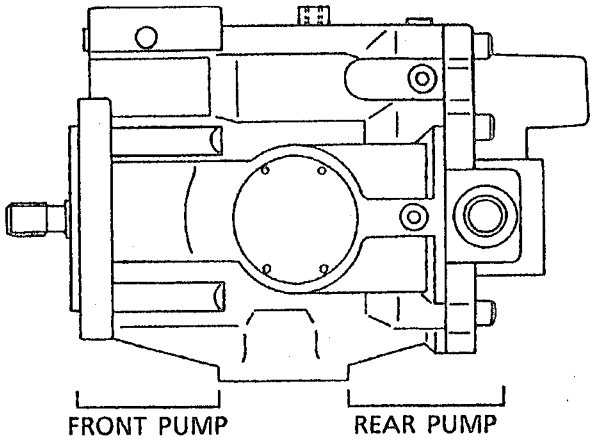

FRONT PUMP
REAR PUMP

Fig. 12

3.2.2 DISASSEMBLY PROCEDURE

(1) Removing gear pump (G1) or (G2+G1)

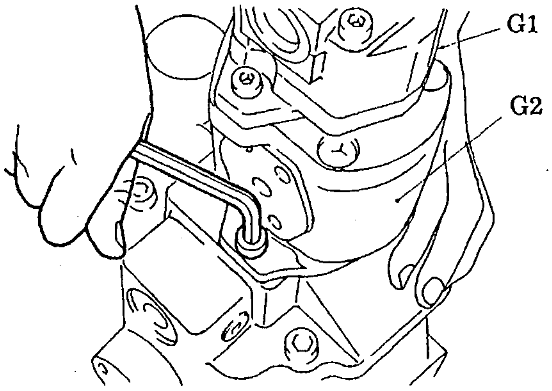


Fig. 13

(2) Removing the piston pump cover

1) Remove socket head capscrews (408) (5 pcs).
2) Dismantle cover (401).

☞ Since spring action is working in the cylindrical part of the cover, exercise care so as not to pry the shaft and the bearing.

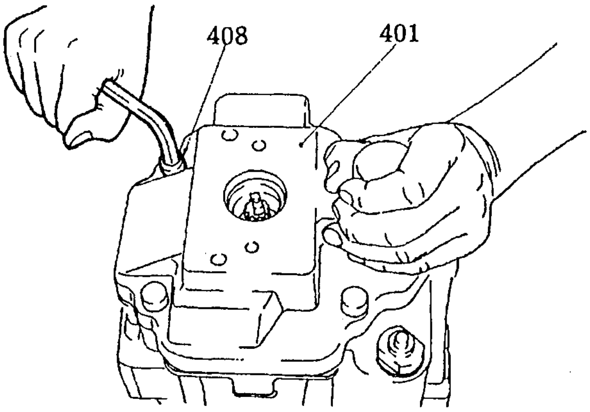


Fig. 14

(3) Disassembling the control body

1) Take off spring seat (112), spring (120) and spring seat (111) that are longer than the hole in Fig. 15.

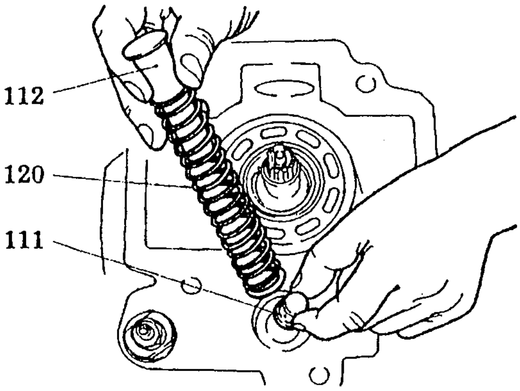


Fig. 15

2) Separate guide (114).

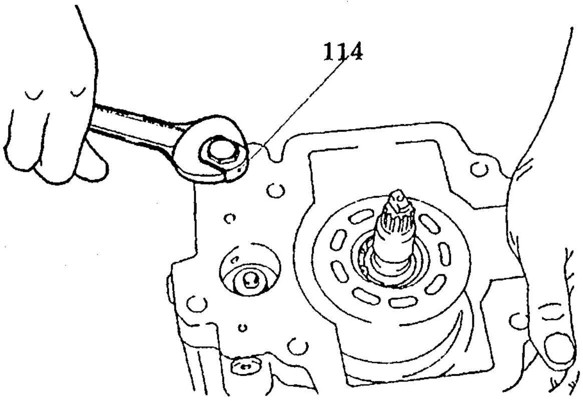


Fig. 16

3) Take off spring (118) and spring seat (110).

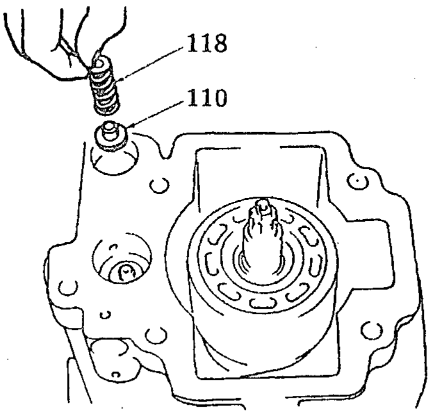


Fig. 17

4) Draw out spool (106), utilizing a steel wire.

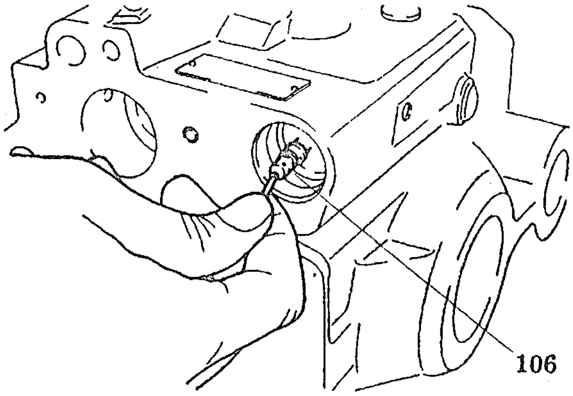


Fig. 18

5) Place the jig in the depth of barrel (107) and draw it out.

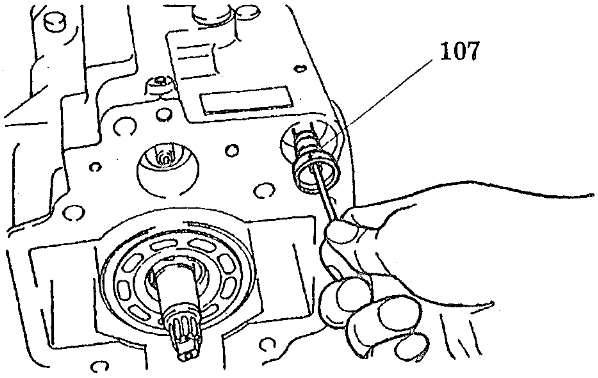


Fig. 19

6) Take out rotary group (3) (rear side) and control piston (103) (smaller diameter side).

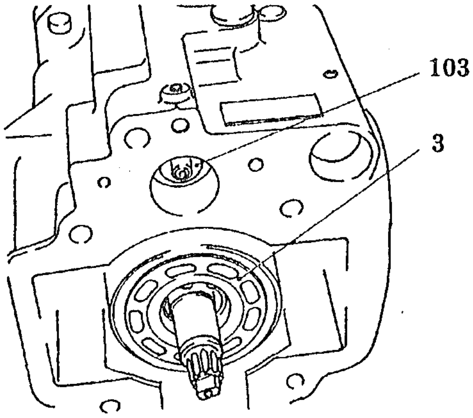


Fig. 20

7) Separate snap ring (12) and seal casing (501). After removing the seal casing, take off shim (11) and O ring (504).

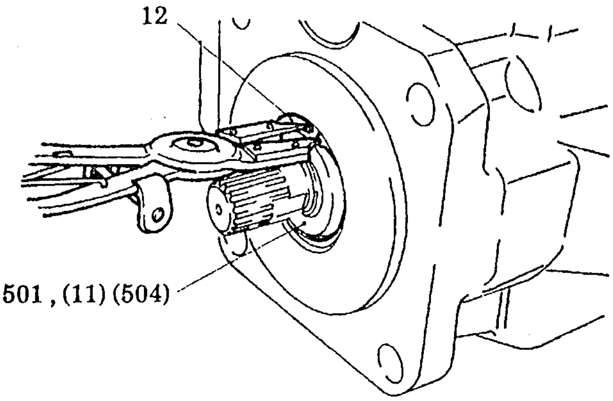


Fig. 21

8) Tap the shaft end with a plastic mallet and draw it out.

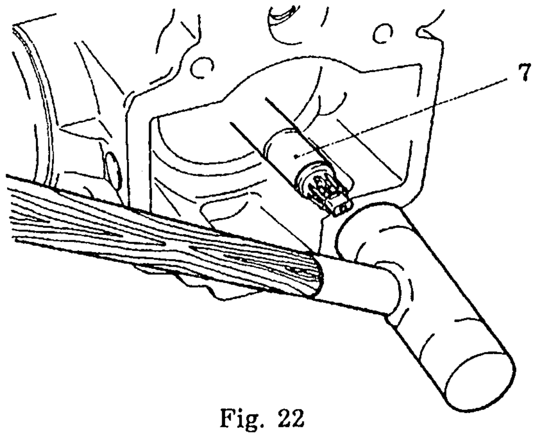


Fig. 22

9) Remove socket head capscrews (211) (4 pcs) fastening cover (204).

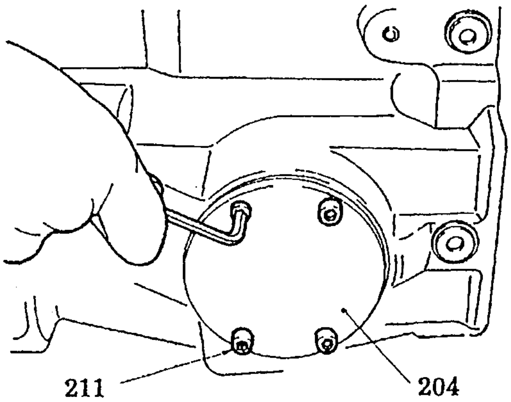


Fig. 23

10) Take off snap ring (207). Then draw out the RH and LH shafts (203) (2 pcs), utilizing cover fastening bolts.

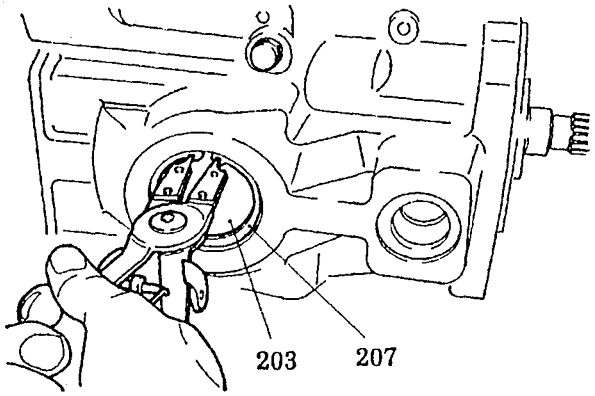


Fig. 24

11) Separate hanger (202).

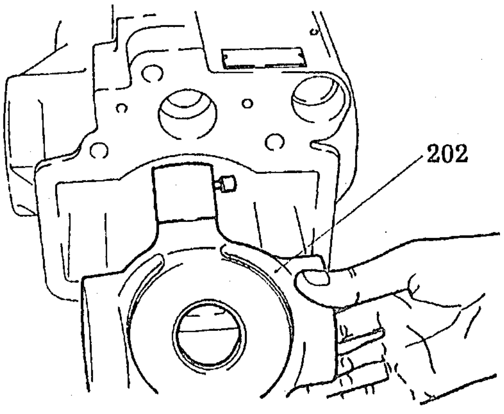


Fig. 25

12) Dismantle rotary group (3) (front side).

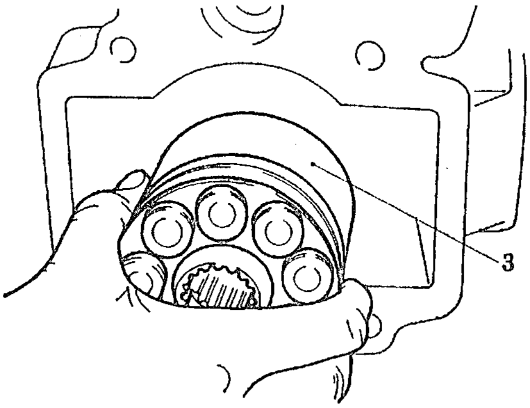


Fig. 26

13) Remove plug (122). Then separate distance piece (105) and control piston (102) (larger diameter side).

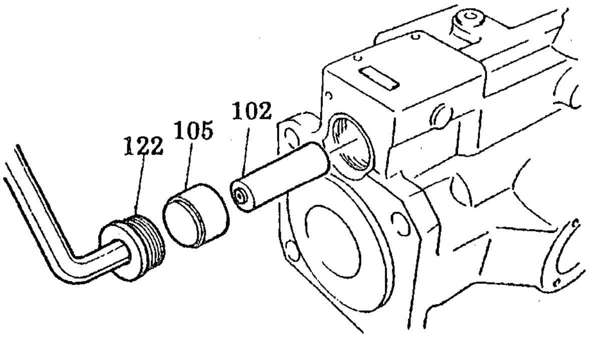


Fig. 27

14) Remove plug (123) and draw out shaft (109), using a jig bolt M5. Then dismantle arm (108) and shim (115).

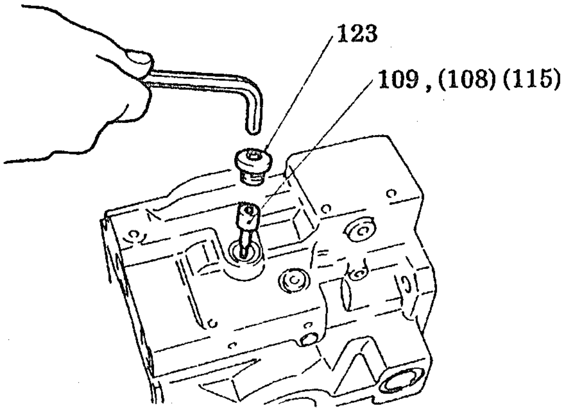


Fig. 28

15) Push piston (104) out of the opposite side (spool side), using a slender steel rod.

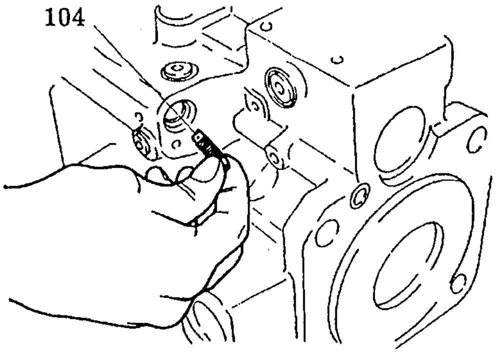


Fig. 29

3.3 ASSEMBLY

3.3.1 GENERAL PRECAUTIONS ON ASSEMBLY

1) Wash all parts thoroughly.
2) During assembly, exercise full care so as not to score parts and to prevent entry of foreign matter.
3) Assemble front and rear pump parts so they may not be mixed up by confirming tags given to them.
4) Do not reuse O rings as a rule.
5) In assembly operation, torques are controlled by the use of a torque wrench.
   Use a torque wrench as much as possible in shop operation.

3.3.2 ASSEMBLY PROCEDURE

(1) Assembling the hanger section

1) Fit plate (305) coated with grease (to prevent fall-off) to hanger (202). (to both the front and rear sides)
2) Fix pilot piston (201) into hanger (202).
   Tightening torque : 0.65kgf · m (4.69ft · lbs)

☞ On that occasion, make sure that plug (208) on the opposite side is not slack.

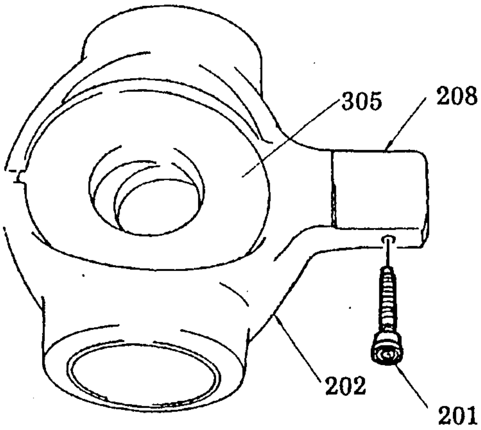


Fig. 30

(2) Assembling the control body

1) Fix shim (115) and arm (108) into housing.

☞ Pay attention to the orientation of the arm.

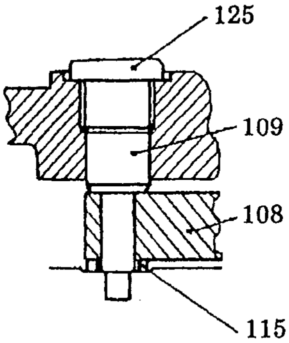


Fig. 31

2) Insert shaft (109) and attach plug (123).
Tightening torque : 5.2kgf · m (38ft · lbs)

☞Make sure that the arm moves smoothly.

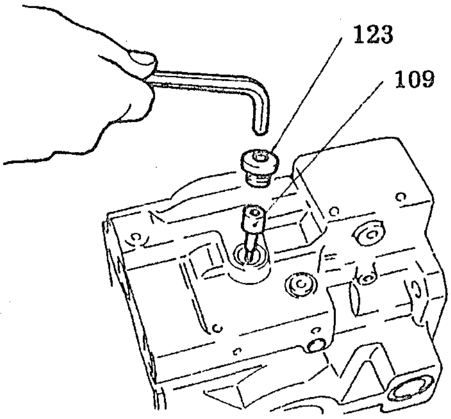
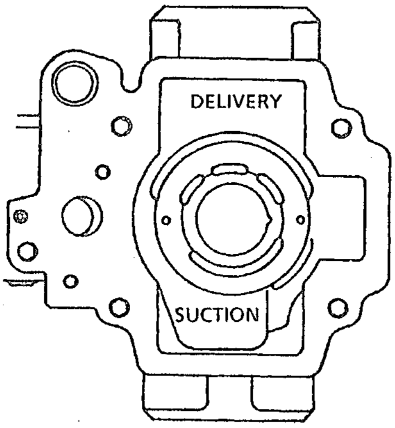


Fig. 32

3) Fix control plate (8) (front side) coated with grease (to prevent fall-off) into housing (101).



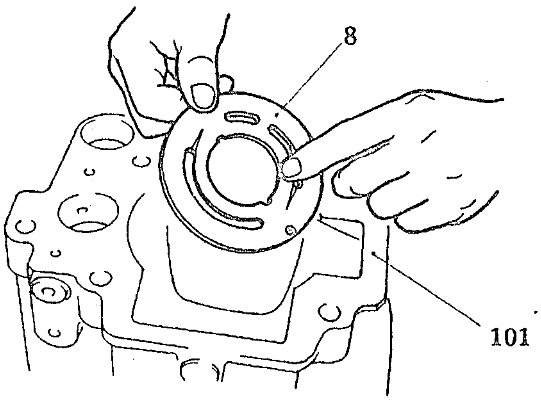


Fig. 33

4) Insert shaft (7) by half of it.

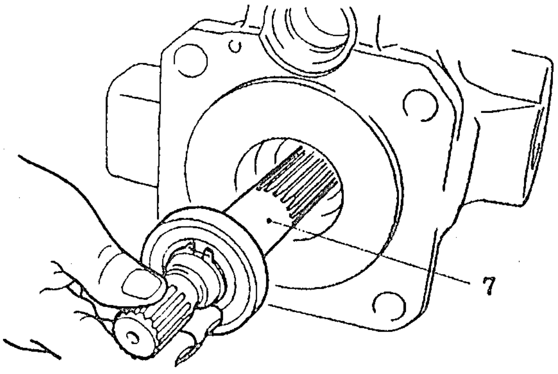


Fig. 34

5) Insert the assembled rotary group (3) (front side) into shaft (7), matching the spline.

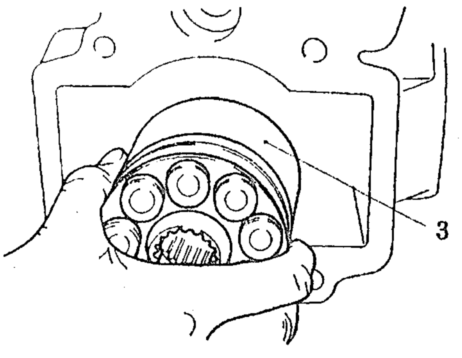


Fig. 35

6) Fit the assembled hanger (202) to housing (101).

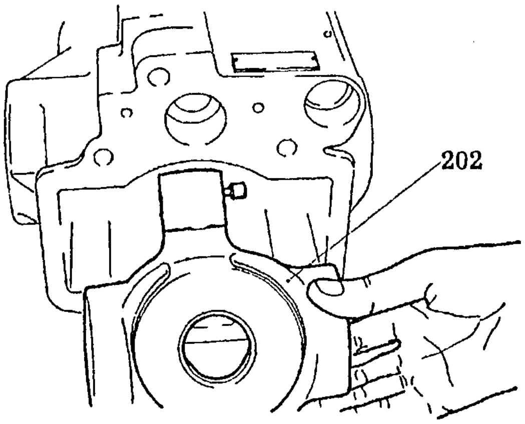


Fig. 36

7) Insert shaft (7) to the full. Then fit shim (11), O ring (504) and oil seal casing (501).

☞ Apply grease to the lip of the oil seal. (grease with molybdenum disulfide)

8) Fix snap ring (12).

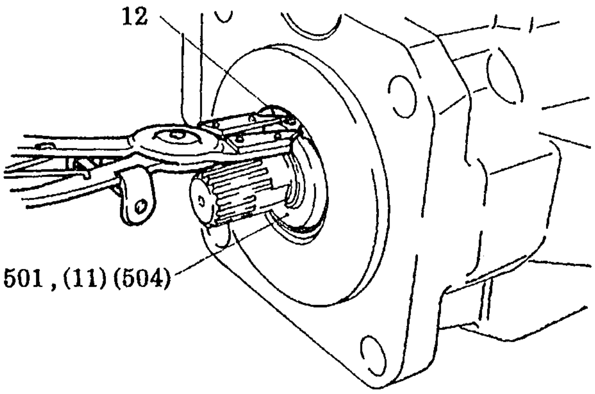


Fig. 37

9) Insert shaft (203) from the side of snap ring (207) and fix it with snap ring (207).

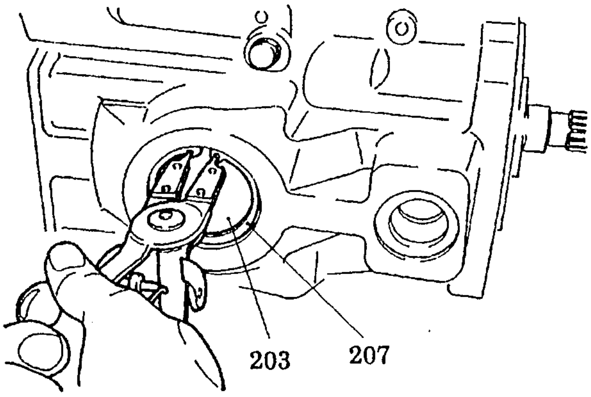


Fig. 38

10) Insert shaft (203) with hanger (202) pressed hard, utilizing the hanger assembling jig.

☞ How to use the jig:
Fix the housing to the jig with M12 bolts (2 pcs) as shown in the figure on the right. Tighten the socket head stop screw, fix the housing so the holes in the housing are aligned to the center of the outer race of the bearing fitted to the hanger and then insert shaft (203).

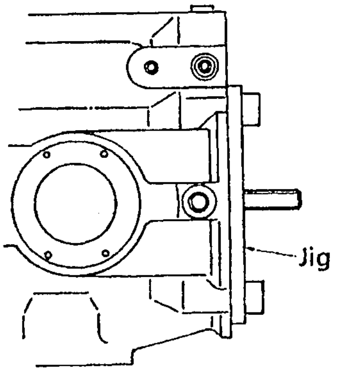


Fig. 39

11) Coat O ring (210) and shim (205) with grease to prevent them from falling off. Plaster the shim to shaft (203) and then fit cover (204) with O ring.

12) Fix cover (204) with socket head capscrews (211) (4pcs).
Tightening torque : 1.2~1.5kgf · m (9~11ft · lbs)

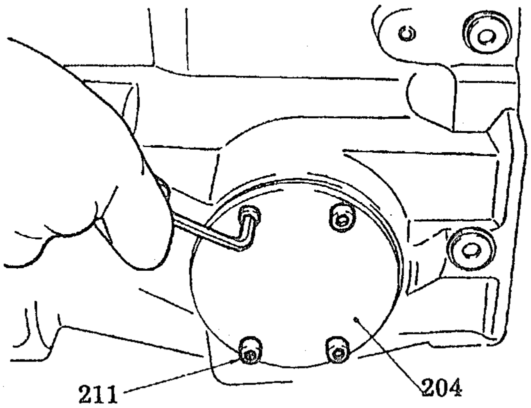


Fig. 40

13) Hold the pump upright and put it into control piston (102) (larger diameter side).

Use a square wooden block or something as a stand to prevent the shaft end from hitting the work bench.

14) Then fit distance piece (105) and plug (122).
Tightening torque : 26kgf · m (188ft · lbs)

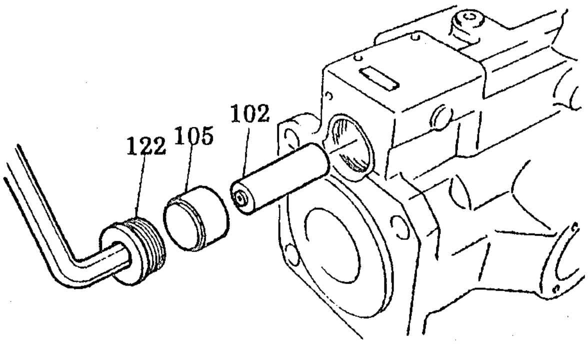


Fig. 41

15) Insert assembled rotary group (3) (rear side) to shaft (7), matching it to the spline.

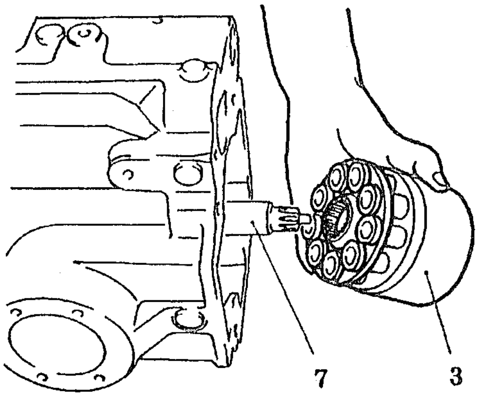


Fig. 42

16) Put in spool (106) and barrel (107).

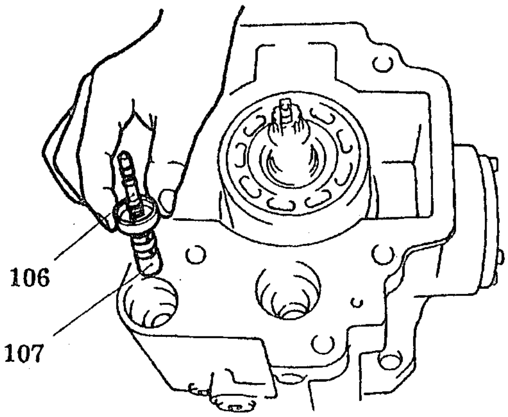


Fig. 43

17) Fit spring seat (110) and spring (118).

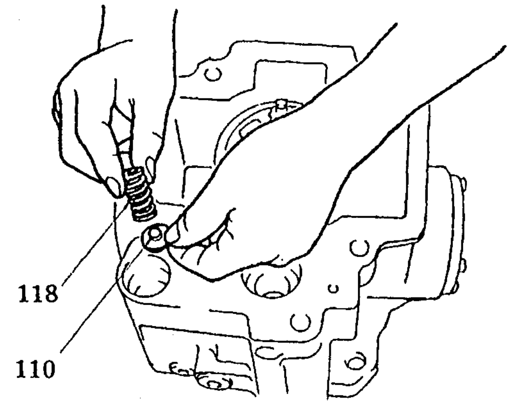


Fig. 44

18) Fit guide (114).
tightening torque : 8kgf · m (58ft · lbs)

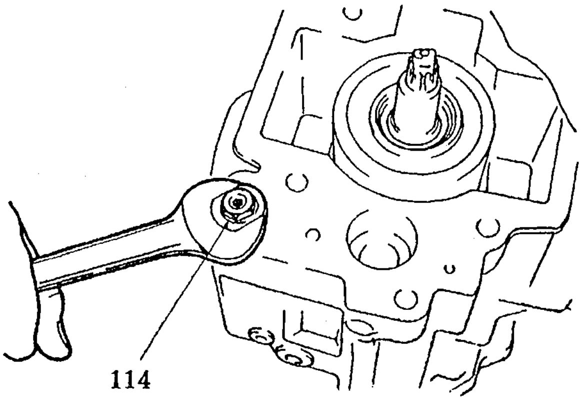


Fig. 45

19) Insert control piston (103) (smaller diameter side).

☞ On that occasion, push in control piston (103) by means of the handle of a hammer and set the hanger to the maximum tilting side.

20) Assemble spring seat (111), spring (120) and spring seat (112) (longer one) in that order.

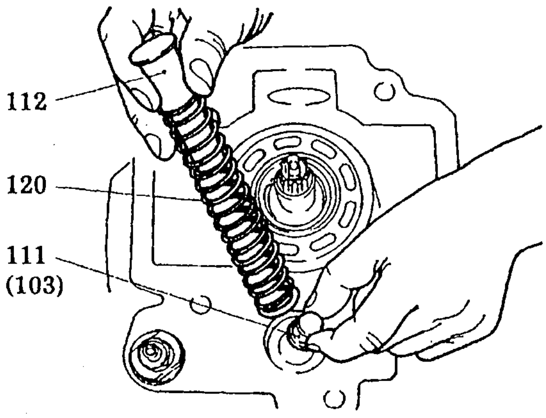


Fig. 46

21) Fix O rings (404) (405) (406) coated with grease (to prevent them from falling off) and control plate (402) (rear side) to the cover.

22) Fit piston pump cover (401) and fix it with socket head capscrews (408).
Tightening torque : 10~12.5kgf · m (72~90ft · lbs)

☞ When fitting cover (401), assemble it by pushing in the cylindrical part of the cover upon which spring action work, exercising care so as not to pry the bearing and the shaft.

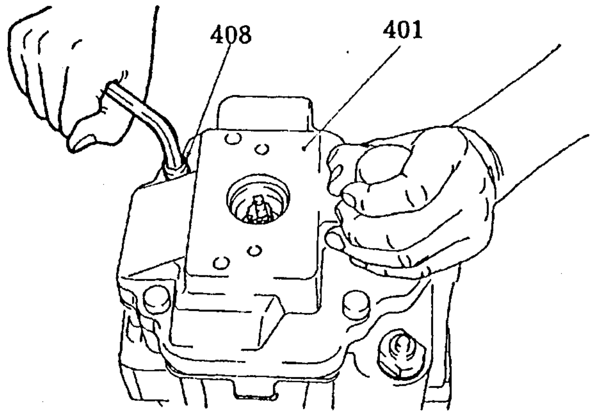


Fig. 47

23) Insert shift piston (104).

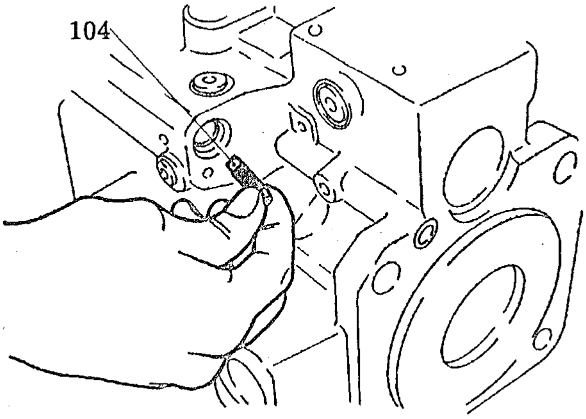


Fig. 48

(3) Insert the assembled double pump into the coupling on the gear pump side.

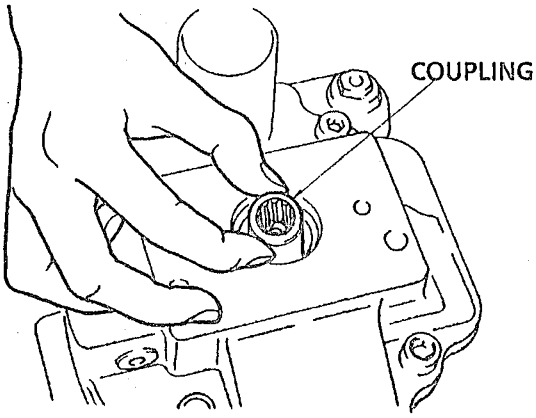


Fig. 49

(4) Connect assembled gear pump (G1) or (G2+G1) with the double pump, using socket head capscrews M10×25 (2 pcs) of the gear pump side.

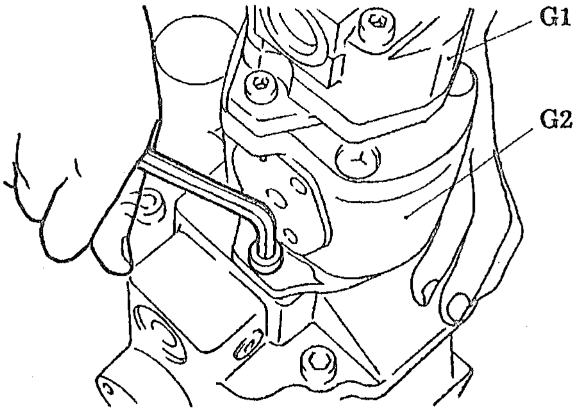


Fig. 50

4. SERVICE STANDARD

4.1 SERVICE STANDARD TABLE

Unit : mm (ft-in)

Name of part	Check and measuring points	Standard value	Correctable value	Allowable limit value	Instrument	Repair and/or remedy
Piston ①, Shoe ②	Gap at caulked part between piston and shoe	0.05 (0.002) max		0.2 (0.01)	Dial indicator	Replace one of which gap exceeds 0.2mm (0.01).
Piston ①, Cylinder block ③	Clearance between piston O. D. and bore of cylinder block	Max. Clearance 0.035 (0.0014)		Clearance 0.05 (0.002)	Micrometer Air micrometer	Replace piston (incl. shoe) or cylinder block or both.
Shoe ②	Thickness of shoe	$4^{0}_{-0.01}$ $\left(0.1575\ ^{0}_{-0.004}\right)$		3.8 (0.15)	Slide calipers	Replace one that is less than 3.8mm (0.15) in thickness.
Shaft ④	Contact area of oil seal lip			Amount of wear : 0.025mm (0.001) max.	Surface roughness meter	Replace one of which wear is less than 0.025mm (0.001).
	Spline				Visual check	Check gear surface by dye penetrant exam. Replace one that shows cracking. Replace one that shows abnormal wear or scoring on the gear surface.
Cylinder block ③	Sliding surface of the control plate of the cylinder block	Ra = 0.2 (0.008) or below	Ra = 0.8 (0.03) or below	Ra = 0.8 (0.03)	Surface roughness meter	If surface roughness exceeds Ra = 0.8 (0.031), correct surface on a lapping machine till Ra = 0.8 (0.031) or below.
Control plate ⑤	Sliding surface of control plate of cylinder block	Ra = 0.2 (0.008) max.	Ra = 0.8 (0.03) max.	Ra = 0.8 (0.03)	Surface roughness meter	If surface roughness exceeds Ra = 0.8 (0.031), correct surface on a lapping machine till Ra = 0.8 (0.031) or under.
Barrel ⑥, Spool ⑦	Clearance between barrel and spool	0.013 (0.0005)		0.025mm (0.001)	Micrometer Cylinder gauge	Replace one of which clearance exceeds 0.025mm (0.001) or one that has abnormal wear or scratch which obstructs smooth movement.
Housing ⑧, Piston ⑨	Clearance between housing and piston	0.025 (0.001)		0.040mm (0.0016)	Micrometer Cylinder gauge	Replace one of which clearance exceeds 0.040mm (0.0016) or one that has wear or scratch which obstructs smooth movement.

Unit : mm (ft-in)

Name of part	Check and measuring points	Standard value	Correctable value	Allowable limit value	Instrument	Repair and/or remedy
Hanger ⑩ Pilot piston ⑪	Clearance between hanger and pilot piston	0.0115 (0.0005)		0.022mm (0.0009)	Micrometer Cylinder gauge	Replace one of which clearance exceeds 0.022mm (0.0009) and one that shows abnormal wear or scratch which obstructs smooth movement.
Housing ⑧ Control piston (A)-⑫ ,(B)-⑬	Clearance between housing and control piston (A) or (B)	0.0275 (0.0011)		0.040mm (0.0016)	Micrometer Cylinder gauge	Replace of which clearance exceeds 0.040mm (0.0016) or one that shows abnormal wear or scratch which obstructs smooth movement.

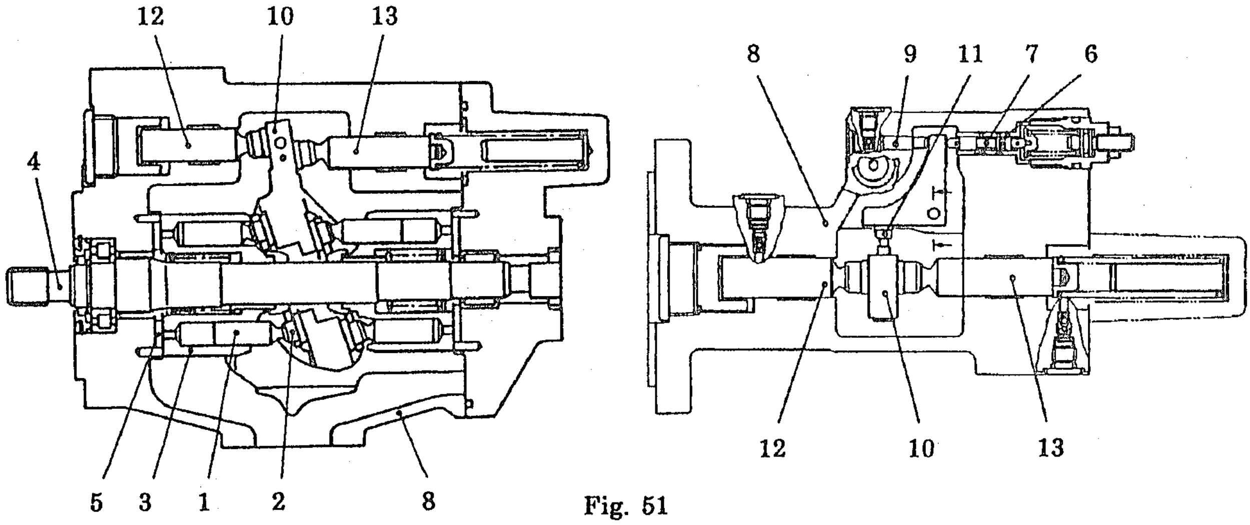


Fig. 51

4.2 INSPECTION AND MEASUREMENT

(1) Piston ass'y and cylinder block

1) Visual appearance check
There shall be no scoring, seizure, abnormal wear, etc. (in particular, the sliding surface)

2) Confirm the clearance between the piston O. D. and the bore of the cylinder block.
$D - d \leqq 0.050$mm (0.002in)

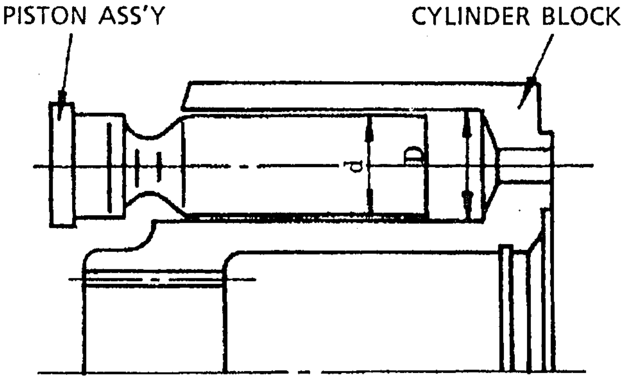

PISTON ASS'Y
CYLINDER BLOCK
d
D

FIG. 52

3) Confirm the play in the axial direction of the piston and the shoe.
$\varepsilon \leqq 0.2$mm (0.01in)

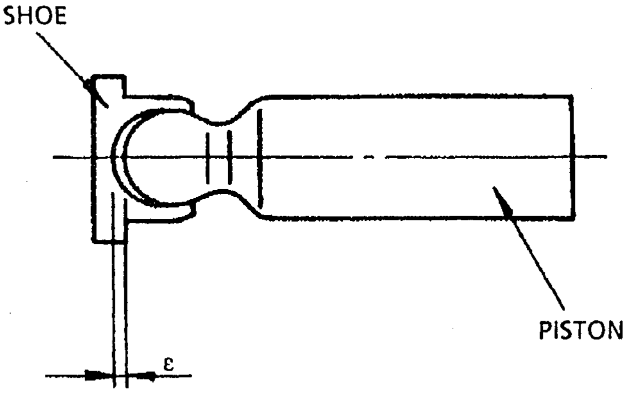

SHOE
PISTON
ε

Fig. 53

(2) Shaft

1) Confirm the amount of wear on the mounting part of the oil seal
The amount of wear$\leqq 0.025$mm (0.001in)

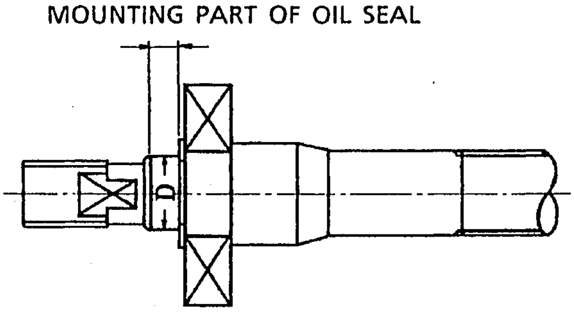

MOUNTING PART OF OIL SEAL
D

Fig. 54

4.3 PUMP CONTROL CURVE

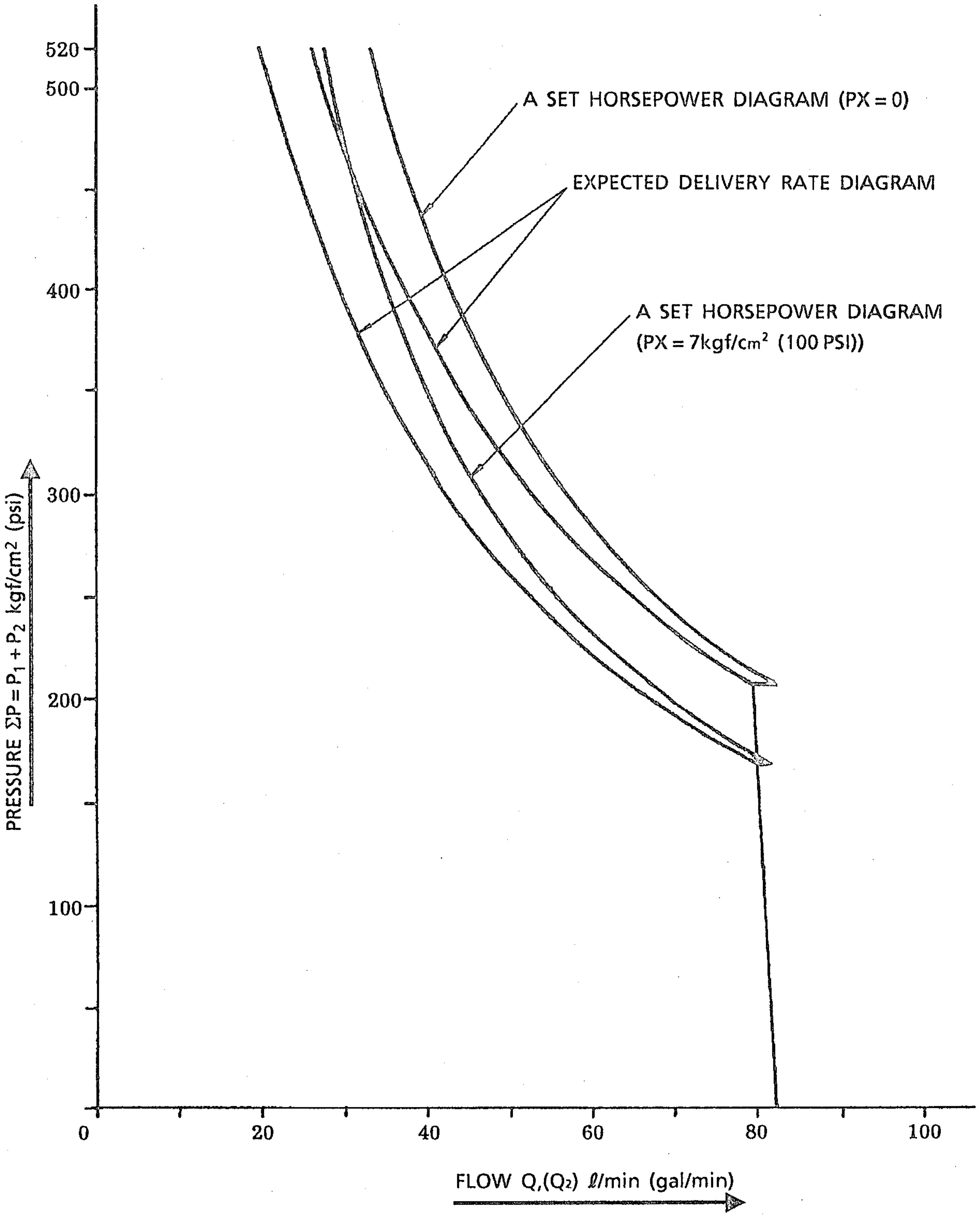


Fig. 55

5. TROUBLESHOOTING

Trouble	Cause	Remedy and corrective action
Abnormal noise	① Air is sucked as oil level falls.	◎ Refill hydraulic oil.
	② Suction pressure loss increases due to clogging of filter.	◎ Clean or replace elements.
	③ Suction pressure loss increases as the viscosity of hydraulic oil rises at low temperature.	◎ Bring oil level to normal level and replace hydraulic oil.
	④ Revolution of input shaft is higher than specified.	◎ Readjust revolution.
	⑤ Mechanical damage, such as damage to bearings.	◎ Replace damaged parts or pump. ● Set pressure again. ● Set flushing of circuits. ● Replace hydraulic oil.
Oil flow is short	① Revolution of input shaft has fallen.	◎ Readjust revolution.
	② Oil temperature is abnormally high.	◎ Re-check temperature when it falls after operation stops.
	③ Viscosity is abnormally high.	◎ Replace with an oil type of suitable viscosity.
	④ Leakage from selector valves and actuators increases.	◎ Replace selector valves and actuators.
	⑤ Volumetric efficiency of pump has fallen.	◎ Replace pump.
	⑥ Horsepower setscrew is loosened.	◎ Reset and lock.
	⑦ Air is inhaled as oil level falls.	◎ Replenish hydraulic oil.
	⑧ Suction pressure loss increases as filter is clogged.	◎ Clean or replace elements.
	⑨ Suction pressure loss increases as the viscosity of hydraulic oil rises at low temperature.	◎ Replace hydraulic oil that gives proper oil temperature.
Pressure does not rise	① A set point of relief valve has fallen.	◎ Reset relief valve.
	② Leakage from selector valves and actuators increases.	◎ Replace faulty selector valve and actuator.
	③ Volumetric efficiency of pump has fallen.	◎ Replace pump.
Overload at static load	① A set horsepower of pump has risen.	◎ Reset on a bench or by the sound from prime mover
	② Control device does not work well.	◎ Correct scoring due to inclusion of foreign matter or replace faulty part.
	③ Mechanical damage such as damage to bearings.	◎ Replace damaged part of pump.
Revolution has fallen at dynamic load	① Peak pressure builds up as responsibility of relief valve lowers.	◎ Replace relief valve. ● Remove foreign matter.
	② Responsibility of control device has fallen.	● Remove foreign matter. Correct scoring caused by inclusion or replace valve.
Abnormal heat generation	① Leakage from pump increases.	◎ Replace pump.
	② Mechanical damage, such as damage to bearings.	◎ Replace damaged part or pump.
	③ Moving surface is seized.	◎ Replace damaged part or pump.
Oil leakage	① O ring or packing is damaged.	◎ Replace sealing material.
	② Oil seal is damaged.	◎ Replace sealing material.
	③ Contact surface of oil seal on input shaft is worn off.	◎ Replace input shaft or pump.
	④ Plugs are slack.	◎ Retighten or replace sealing material.

Book code No. S5 12037 1E

KOBELCO

SHOP MANUAL

HYDRAULIC GEAR PUMP

12

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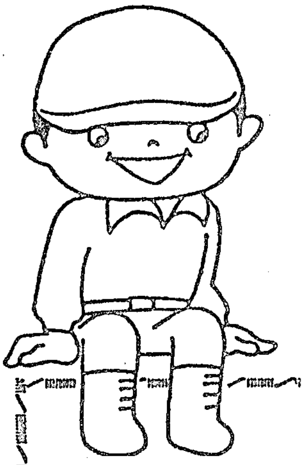
KOBE STEEL, LTD.



PREFACE

The hydraulic pump sucks hydraulic oil, pressurizes it and delivers it to related equipment. The pump is a small capacity gear pump and is utilized when a small capacity hydraulic source is needed in addition to the main pump.

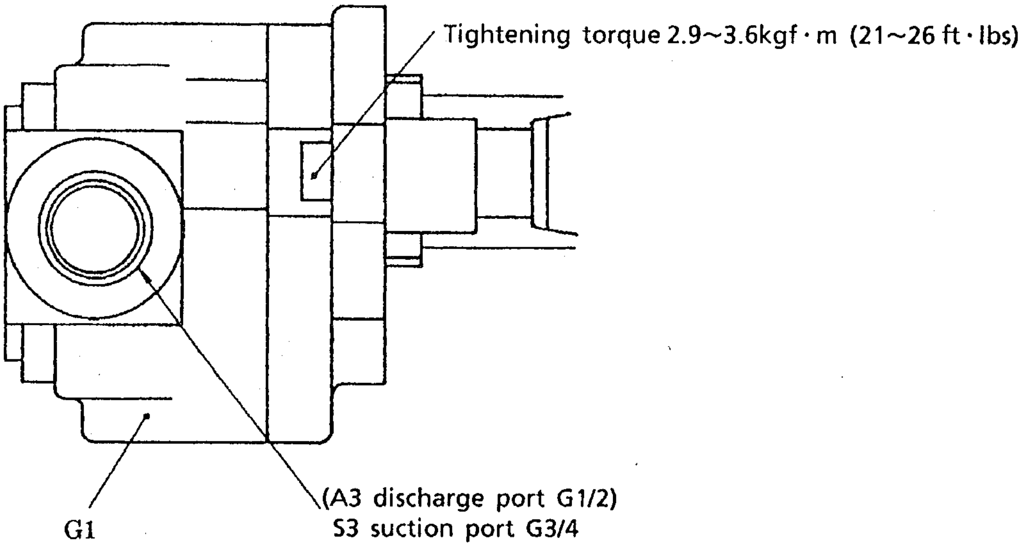
Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	June, 1990	S5120371E K

1. SPECIFICATION

1.1 APPEARANCE

1.1.1 STANDARD SPECIFICATION


Tightening torque 2.9~3.6kgf·m (21~26 ft·lbs)
G1
(A3 discharge port G1/2)
S3 suction port G3/4

1.1.2 OPTIONAL SPECIFICATION

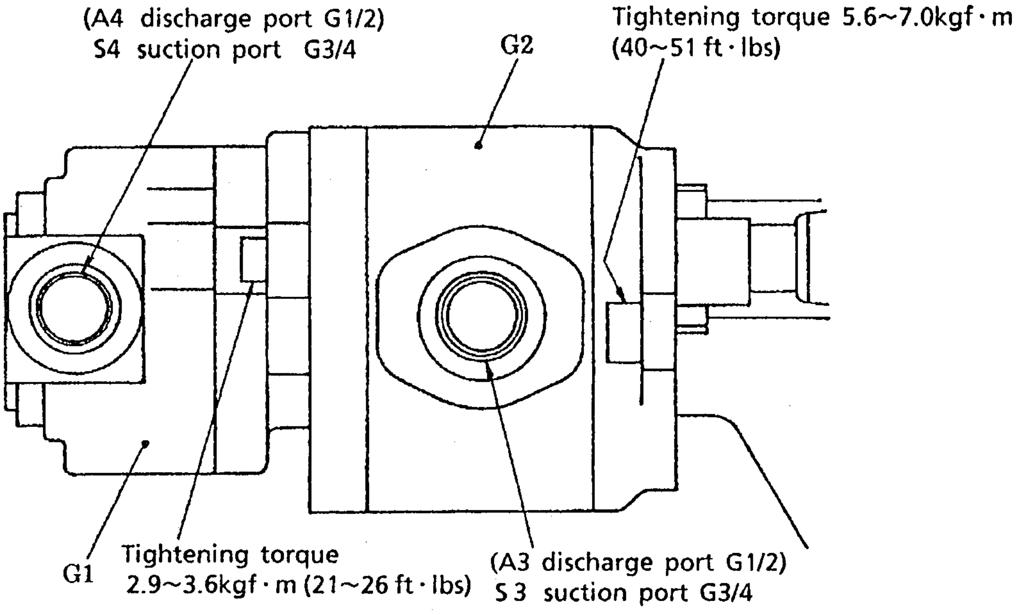

(A4 discharge port G1/2)
S4 suction port G3/4
G2
Tightening torque 5.6~7.0kgf·m
(40~51 ft·lbs)
G1
Tightening torque
2.9~3.6kgf·m (21~26 ft·lbs)
(A3 discharge port G1/2)
S3 suction port G3/4

Fig. 1

1.2 PRINCIPAL PARTICULARS

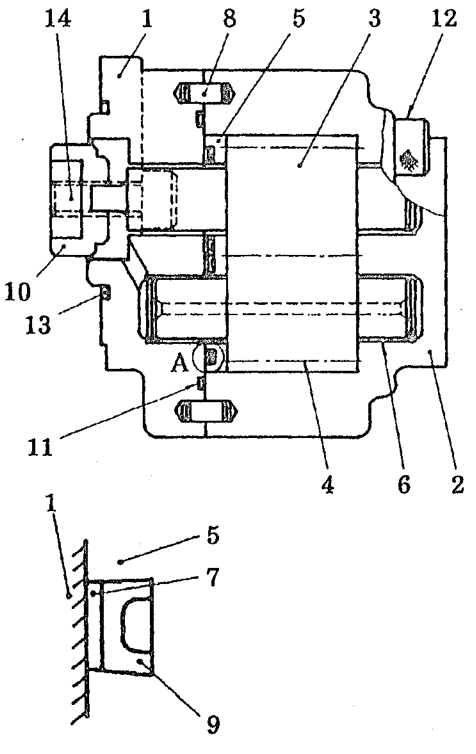
Table 1

Item \ Model		G1-09R-10-984-0	G2-C1S12TR-10-975-0 (Option)
Displacement capacity	cc/rev. (cuin/rev)	8.9 (0.543)	12.1 (0.738)
Rated pressure	kgf/cm² (psi)	35 (498)	200 (2840)
Rated revolution	rpm	2200	←
Max. flow	ℓ/min (gal/min)	19.6 (5.17)	26.6 (7.02)

2. CONSTRUCTION

2.1 CONSTRUCTION

2.1.1 G1 GEAR PUMP (STANDARD)


14
1
8
5
3
12
10
13
A
11
4
6
2
1
5
7
9

DETAIL A

Fig. 2

2.1.2 G2+(G1) GEAR PUMP OPTION)

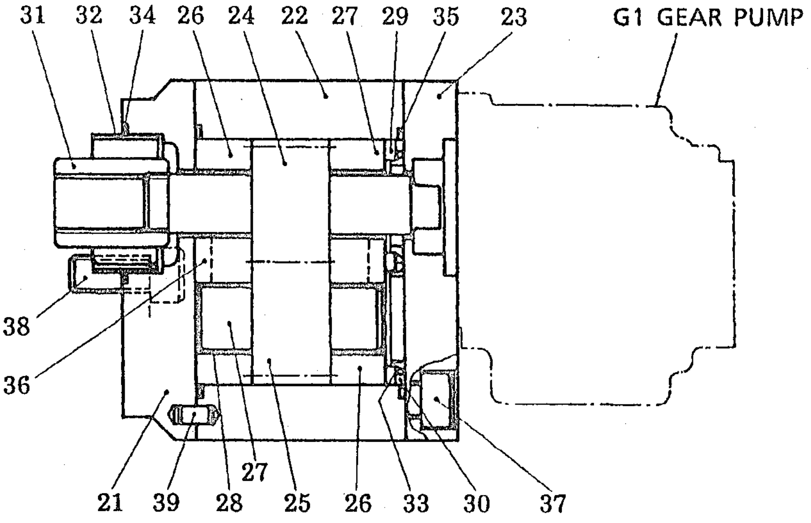

31
32
34
26
24
22
27
29
35
23
G1 GEAR PUMP
38
36
21
39
28
27
25
26
33
30
37

Fig. 3

Table 2

G1 gear pump			G2 gear pump		
No.	NAME	Q' ty	No.	NAME	Q' ty
1	FRAME	1	21	FRAME	1
2	HOUSING	1	22	CASING	1
3	GEAR (DRIVE)	1	23	FRAME	1
4	GEAR (IDLE)	1	24	GEAR (DRIVE)	1
5	SIDE	1	25	GEAR (IDLE)	1
6	METAL	4	26	SIDE PLATE	2
7	BACKUP RING	1	27	SIDE PLATE	2
8	PIN	2	28	METAL	4
9	SQUARE RING	1	29	PLATE	1
10	COUPLING	1	30	GUIDE	2
11	O RING	1	31	COUPLING	1
12	SOCKET BOLT	4	32	BUSHING	1
13	O RING	1	33	O RING	2
14	SOCKET BOLT	2	34	O RING	1
			35	SQUARE RING	2
			36	SQUARE RING	2
			37	SOCKET BOLT	4
			38	SOCKET BOLT	2
			39	PIN	4

3. DISASSEMBLY AND ASSEMBLY

3.1 DISASSEMBLY

3.1.1 GENERAL PRECAUTIONS TO BE EXERCISED ON DISASSEMBLY

1) Avoid turning the adjust screw in any circumstances except when necessary : Other-wise, a set horsepower varies and has adverse effect on the excavator.
2) Exercise full care so as not to hit parts or fall them during disassembly.
3) The front and rear pumps are composed of conditioned parts. Attach a tag to each of the parts so they may not be mixed up.

3.1.2 DISASSEMBLY PROCEDURE

(1) Dismantle gear pump (G1) from the machine body.

(2) Disassembling gear pump.

1) Remove socket bolt (12) (4 pcs) that fastens housing (2) to frame (1).

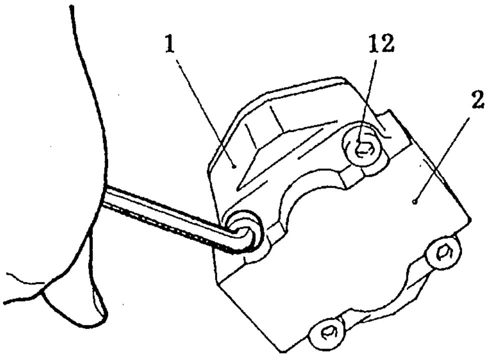


Fig. 4

2) Separate side plate (5), square ring (9), backup ring (7) and gear (3) as if you draw out gear (drive side) (3).

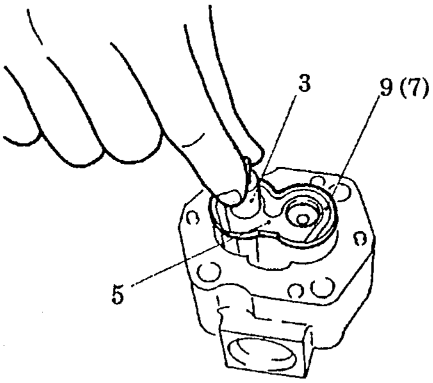


Fig. 5

3) Dismantle gear (idle side).

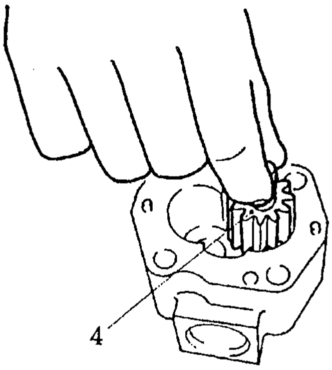


Fig. 6

3.1.3 PROCEDURE FOR DISASSEMBLING OPTIONAL SPECIFICATIONS

(1) Remove gear pump (G2).

1) Remove socket bolt (38) (2 pcs) that fasten gear pump (G2) to the machine body.

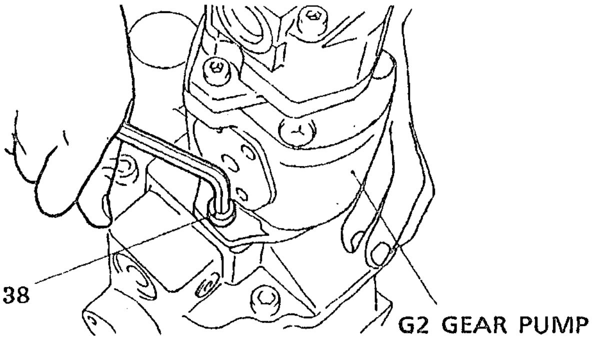


Fig. 7

(2) Disassembling gear pump (G2)

1) Remove socket bolt (14) (2 pcs) fastening gear pump (G1).

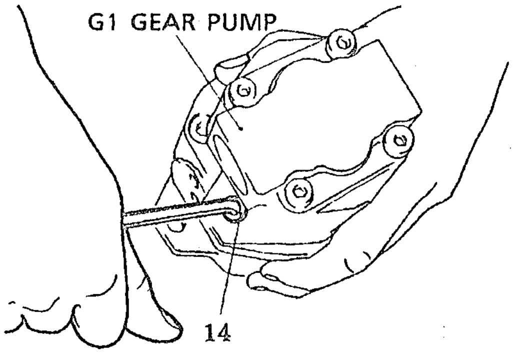


Fig. 8

2) Remove coupling (31) and then take off socket bolt (37) (4 pcs) fastening frame (23).

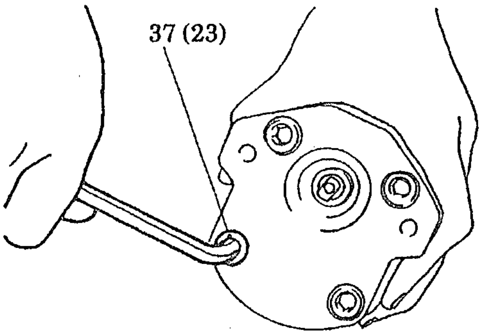


Fig. 9

3) Separate square ring (35), guide (30) and O ring (33).

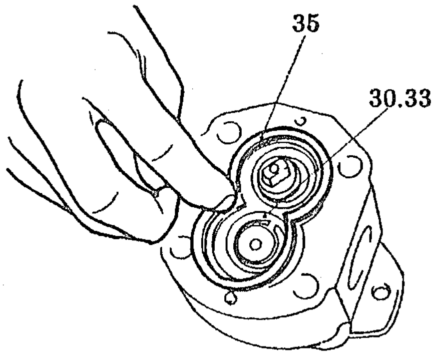


Fig. 10

4) Dismantle plate (29), push out the gear (drive side) from the opposite side and then remove gear (24) side plates (26, 27).

☞ Take care square ring (36) fastening side plates (26, 27) does not fall off.

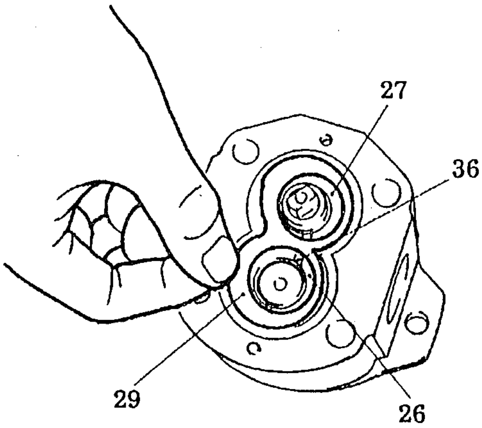


Fig. 11

5) Remove gear (idle side) (25).

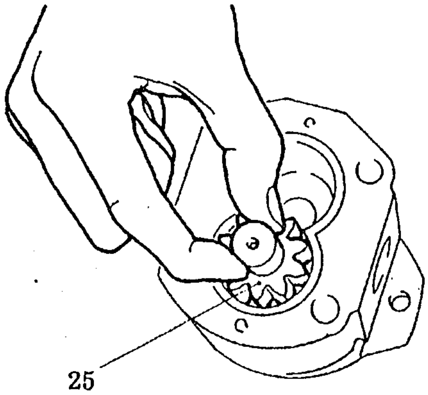


Fig. 12

6) Remove side plates (26, 27).

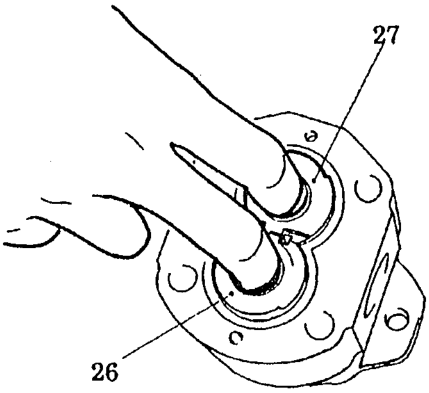


Fig. 13

3.2 ASSEMBLY

3.2.1 ASSEMBLY PROCEDURE

(1) Assembling gear pump (G1).

1) Assemble gears (drive side, idle side) (3) (4) to housing (2).

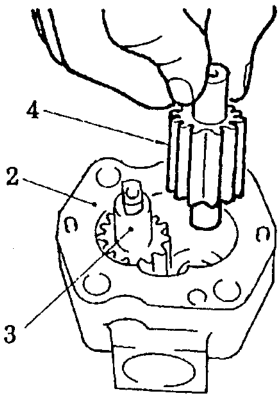


Fig. 14

2) Coat square ring (9) and backup ring (7) with grease to prevent them falling off and fix them to side plate (5).

3) Fit assembled side plate (5) to housing (2).

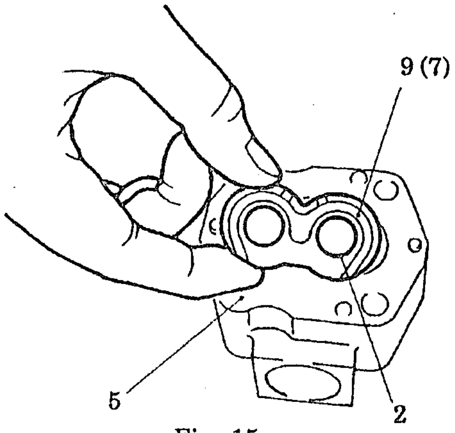


Fig. 15

4) Match housing with parts to frame (1) and fasten them with socket bolt (12) (4 pcs).
Tightening torque : 2.9~3.6kgf·m (21~26 ft·lbs)

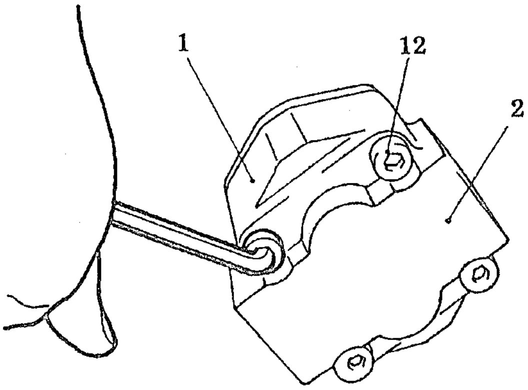


Fig. 16

3.2.2 PROCEDURE FOR ASSEMBLING OPTIONAL SPECIFICATIONS

(1) Assembling gear pump (G2)

1) Fit square ring (35) to prevent it from falling off and match frame (23) to casing (22).
2) Fit side plates (26, 27) and insert gear (drive side).

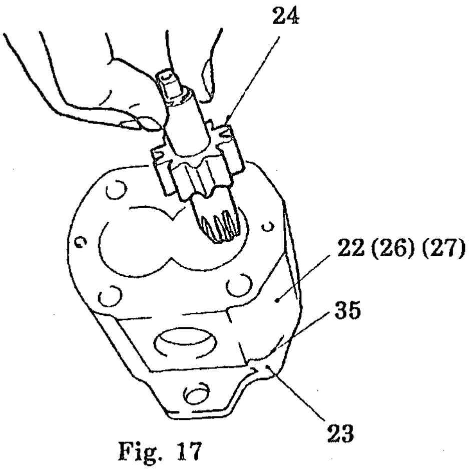


Fig. 17

3) Insert gear (idle side) (25).
4) Fit side plates (26, 27).

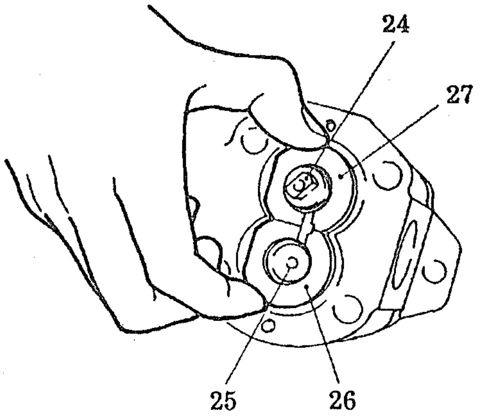


Fig. 18

5) Fit plate (29), guide (30) and O ring (33). Then fit square ring (36) coated with grease to prevent it from falling off.

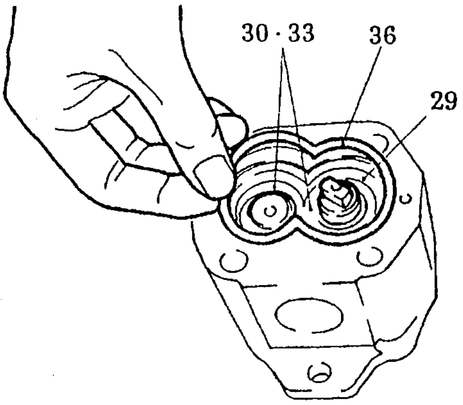


Fig. 19

6) Fix frame (23) with socket bolt (37) (4 pcs).
Tightening torque : 5.6~7kgf·m (40~51 ft·lbs)

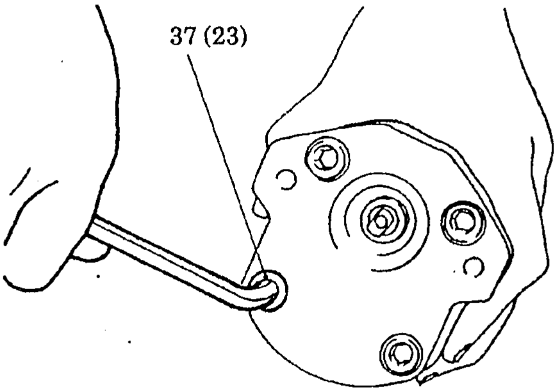


Fig. 20

7) Match coupling (10) with gear (drive side) (24), connect gear pump (G2) with gear pump (G1) and tighten them with socket bolt (14) (2 pcs).

☞ Where gear pump (G2) is not present, attach gear pump (G1) to the double pump. This completes assembly.

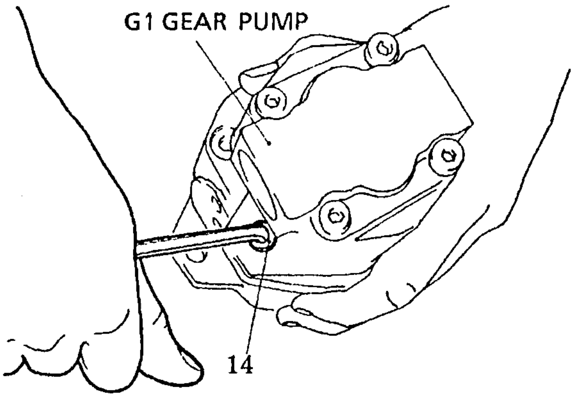


Fig. 21

4. TROUBLESHOOTING

Table 3

Trouble	Cause	Remedy
1. Oil leaks through the matching face of gear plate.	1) O ring is faulty.	1) Replace all sealing parts.
2. Oil leak from oil seal	1) Suction pressure is too high. Clearance between gear side face and outer surface of gear is large. 2) Dirt is included in the oil seal lip or the lip is scored or hardened. 3) The area in contact with drive shaft seal is scored or worn.	1) Replace parts causing oil leak. 2) Replace oil seal. 3) Replace drive shaft.
3. Casing temperature is abnormally high.	Square ring is fixed in a wrong direction.	Replace side plates (26,27) and all sealing parts. If seizure is excessive, replace pump assembly.
4. Oil is not discharged.	1) Rotating direction is wrong. 2) Drive gear shaft is broken. 3) Coupling is broken. 4) Air is sucked from suction pipe. 5) Hydraulic oil is short.	1) Check the rotating direction of pump and replace it if the direction is wrong. 2) Replace shaft. 3) Replace coupling. 4) Check joint and retighten. 5) Check oil level in tank and refill as necessary.
5. Pressure does not rise.	Internal leakage is large because of wear of housing (casing) or side plate.	Check if the maximum pressure is produced in idling condition and repair or replace faulty parts.
6. Noise comes up.	Air is being inhaled from suction pipe or drive shaft seal. (Oil in hydraulic oil tank is bubbling.)	Adjust and retighten parts that inhaling air or replace seals. Check oil level in hydraulic oil tank and refill oil if necessary.

KOBELCO

Book code No. S5 13008 2E

SHOP MANUAL

CONTROL VALVE

13

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1.2 Specification 1

2. CONSTRUCTION AND OPERATION

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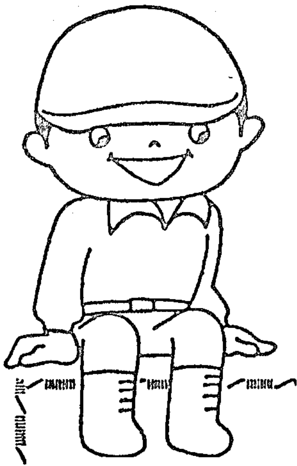
2.2 Operation 2

KOBE STEEL, LTD.



PREFACE

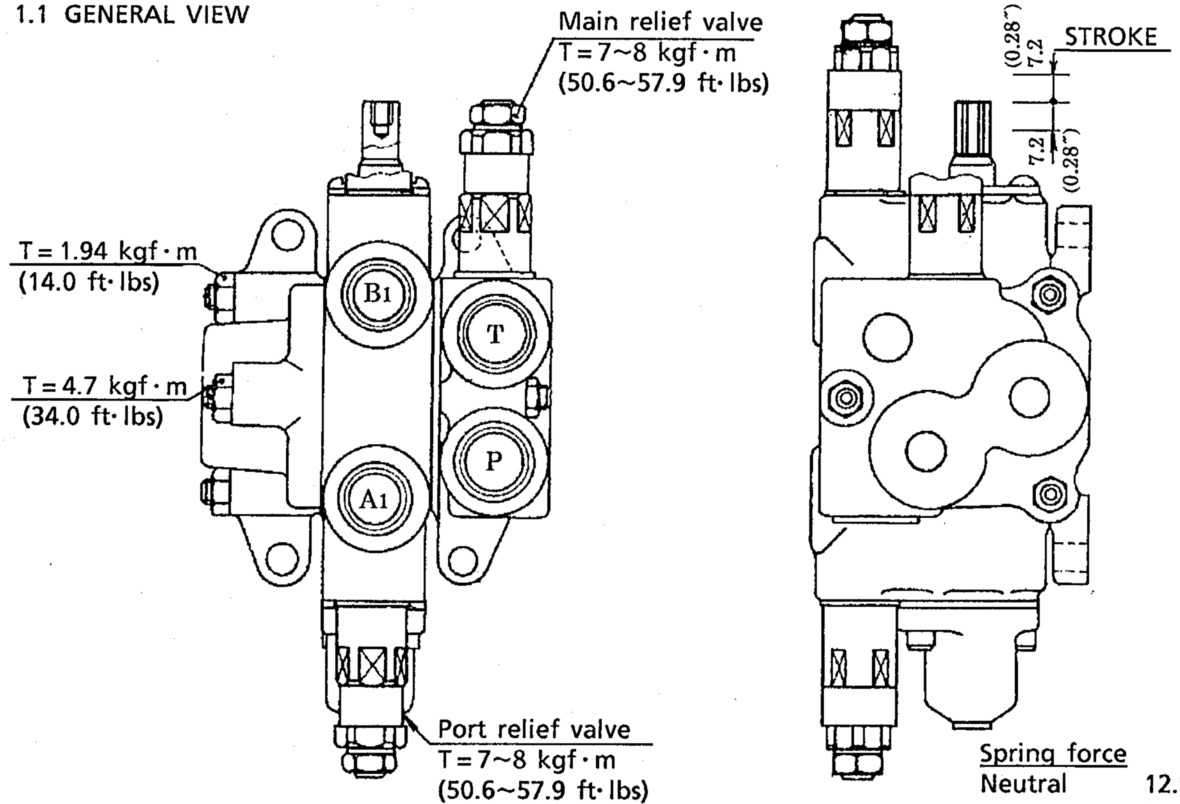
This is a composite valve containing a direction control valve that controls the actuator motion by changing the valve circuit, a relief valve that holds the circuit pressure within a safe pressure range.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	November,1990	S5130082E K

1. SPECIFICATION

1.1 GENERAL VIEW



Main relief valve
T = 7~8 kgf · m
(50.6~57.9 ft· lbs)

T = 1.94 kgf · m
(14.0 ft· lbs)

T = 4.7 kgf · m
(34.0 ft· lbs)

Port relief valve
T = 7~8 kgf · m
(50.6~57.9 ft· lbs)

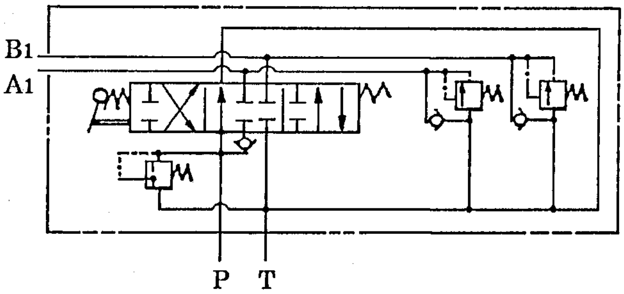
Spring force	
Neutral	12.9 kgf · m (28.4 lbs)
Full stroke	16.2 kgf · m (35.7 lbs)

Fig. 1 Outside view of control valve

PORT NAME

	SIZE	PORT NAME
A1	PF 1/2	Cylinder R side (Dozzer up)
B1	PF 1/2	Cylinder H side (Dozzer down)
P	PF 1/2	Pump port
T	PF 1/2	Tank port

HYDRAULIC CIRCUIT DIAGRAM



1.2 SPECIFICATION

Item	Specification	
Model	KVS-65-1	
Max. Flow late	65 ℓ/min	[17.2 gal/min]
Max. Pressure	210 kgf/cm^2	[2990psi]
Set pressure of main relief valve	200 kgf/cm^2 at 30 ℓ/min	[2840psi at 7.9 gaℓ/min]
Set pressure of port relief valve	A1; 230 kgf/cm^2 at 30 ℓ/min	[3270psi at 7.9 gaℓ/min]
	B1; 230 kgf/cm^2 at 30 ℓ/min	[3270psi at 7.9 gaℓ/min]
Weight	4.9 kg	[10.8 lbs]

2. CONSTRUCTION AND OPERATION

2.1 CONSTRUCTION

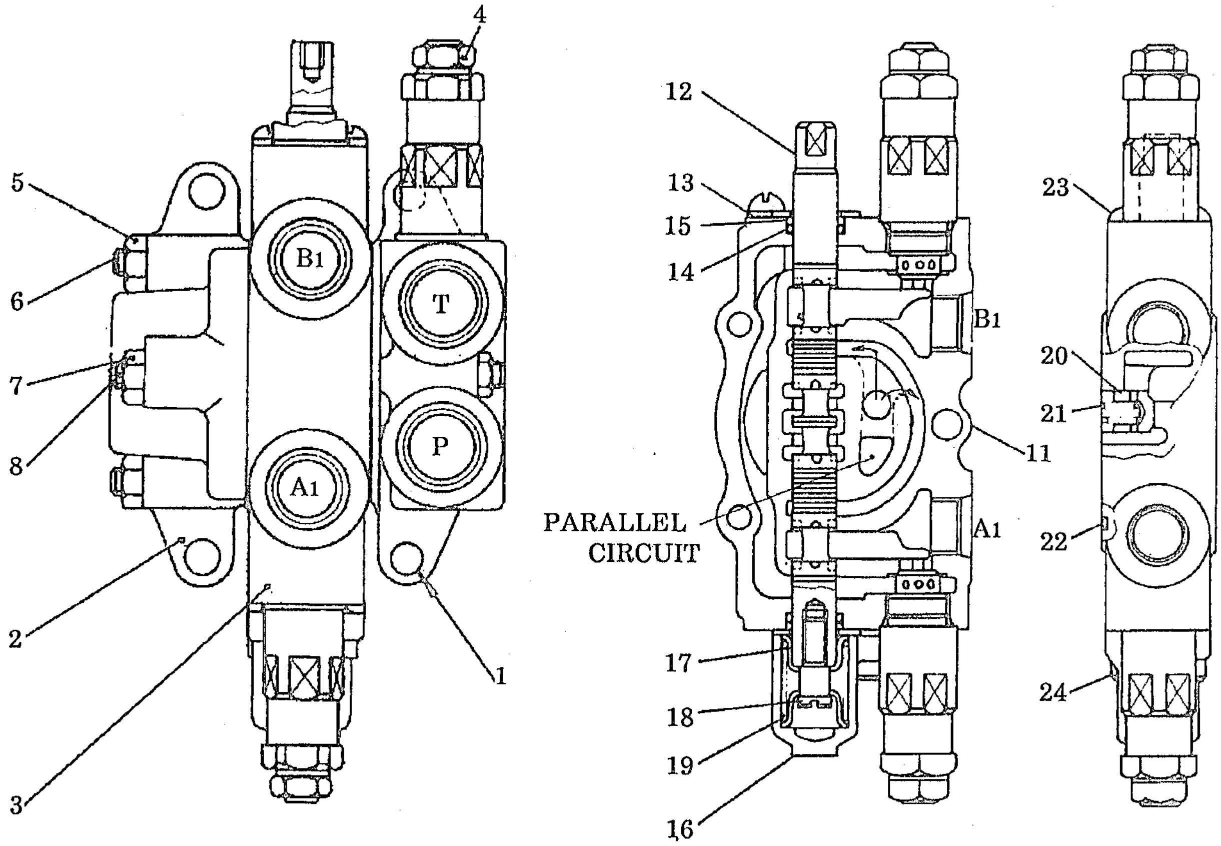


Fig. 2 Sectional view of control valve

No.	Parts Name	Q'ty
1	SECTION ASSY, INLET	1
2	SECTION ASSY, OUTLET	1
3	SECTION ASSY, PLUNGER	1
4	MAIN RELIEF VALVE	1
5	NUT	4
6	TIE ROD	2
7	NUT	2
8	TIE ROD	1
9	PORT RELIEF VALVE	2

No.	Parts Name	Q'ty
11	VALVE HOUSING	1
12	SPOOL	1
13	SEAL PLATE	2
14	O RING	2
15	WIPER	2
16	CAP	1
17	SPRING SEAT	2
18	CAPSCREW	1
19	SPRING	1
20	LOAD CHECK VALVE	1
21	SPRING	1
22	O RING	1
23	MACHINE SCREW	1
24	SOCKET BOLT	2

2.2 FUNCTION

If spool (12) is pushd in, the pressuized oil pushed up load check valve (20) through the parallel connection and is supplied to the cylinder through port B_1

In the meantime, the oil returned from the cylinder is brought back to the tank past port A_1 and the low pressure line.

Operating spool (20) in the reverse direction causes the pressurized oil to flow the opposite way.

Book code No. S5 13045 0E①

KOBELCO

SHOP MANUAL

PILOT VALVE (WRIST CONTROL)

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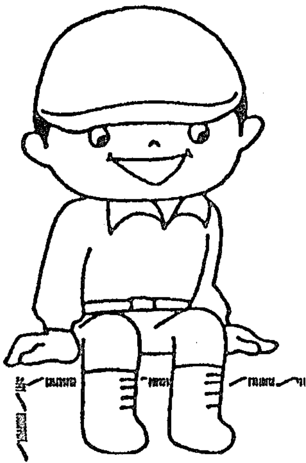
KOBE STEEL, LTD.



PREFACE

The pilot valve is a remote control valve of pressure reducing type that contains multiple pressure reducing valves in its casing to control secondary pressures.
The output pressure varies in proportion to the tilting of the control lever.
The secondary pilot pressure of the high pressure selector valve becomes an auto accel signal.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK100	YW-2801~				
SK120	LP-5201~				
SK120-LC	YP-1601~				
SK200	YN-6501~				
SK200-LC	YQ-1101~				
SK220	LQ-2101~				
SK220-LC	LL-1801~				
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	March, 1990	S5130450E K
First revison	June, 1990	S5130450E① K

1. SPECIFICATION

1.1 GENERAL VIEW

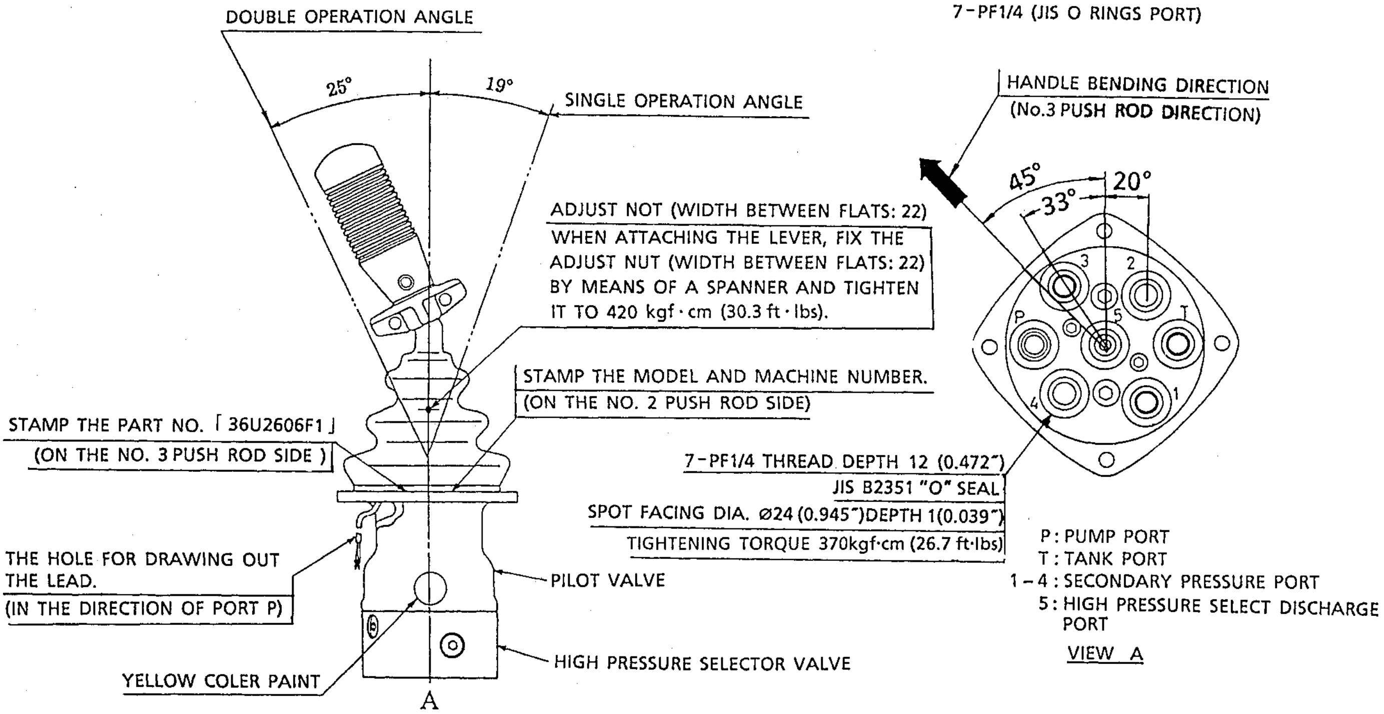

DOUBLE OPERATION ANGLE
25°
19°
SINGLE OPERATION ANGLE
7-PF1/4 (JIS O RINGS PORT)
HANDLE BENDING DIRECTION
(No.3 PUSH ROD DIRECTION)
45°
33°
20°
ADJUST NOT (WIDTH BETWEEN FLATS: 22)
WHEN ATTACHING THE LEVER, FIX THE ADJUST NUT (WIDTH BETWEEN FLATS: 22) BY MEANS OF A SPANNER AND TIGHTEN IT TO 420 kgf·cm (30.3 ft·lbs).
STAMP THE MODEL AND MACHINE NUMBER.
(ON THE NO. 2 PUSH ROD SIDE)
STAMP THE PART NO. 「36U2606F1」
(ON THE NO. 3 PUSH ROD SIDE)
7-PF1/4 THREAD DEPTH 12 (0.472")
JIS B2351 "O" SEAL
SPOT FACING DIA. ø24 (0.945")DEPTH 1(0.039")
TIGHTENING TORQUE 370kgf·cm (26.7 ft·lbs)
THE HOLE FOR DRAWING OUT THE LEAD.
(IN THE DIRECTION OF PORT P)
PILOT VALVE
YELLOW COLER PAINT
HIGH PRESSURE SELECTOR VALVE
A
P
T
1
2
3
4
5
P: PUMP PORT
T: TANK PORT
1-4: SECONDARY PRESSURE PORT
5: HIGH PRESSURE SELECT DISCHARGE PORT
VIEW A

Fig. 1 External views of pilot valve

1.2 SPECIFICATION

Table 1

Primary pilot pressure	50 kgf/cm² (711 psi)
Operating angle	25° 19° (Ports 2, 4) (Ports 1, 3) (Single operation, MAX.)
Weight	6.4kg (14.1 lbs)

1.3 PERFORMANCE CHARACTERISTICS

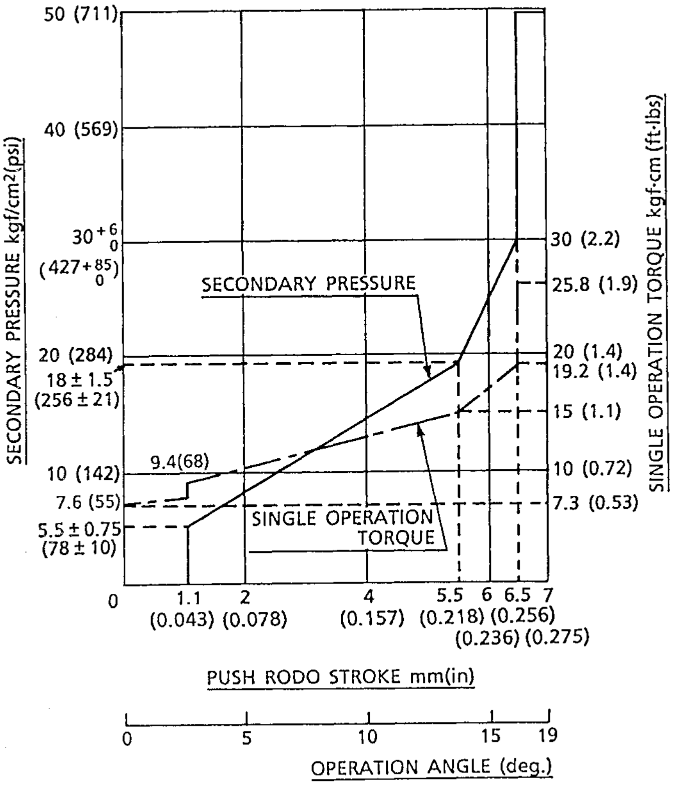
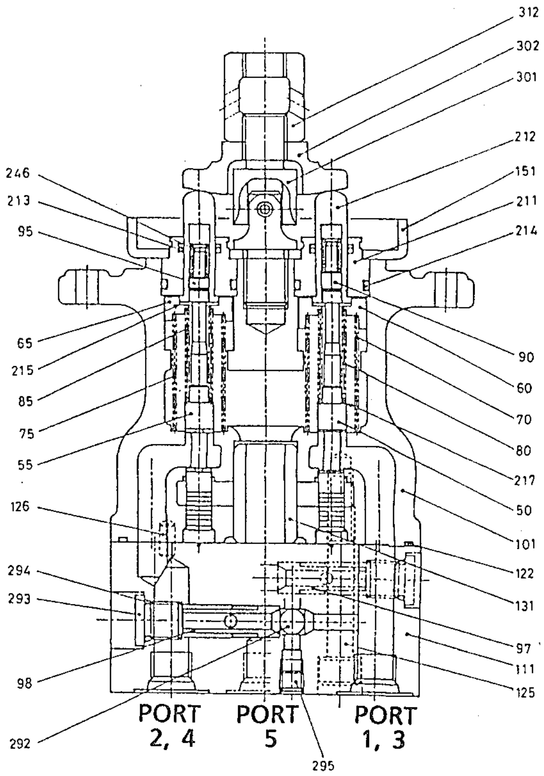
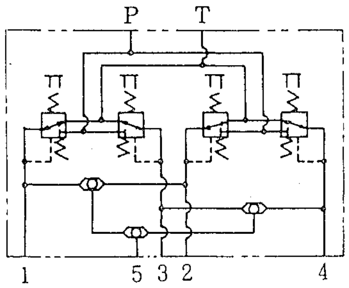


Fig. 2

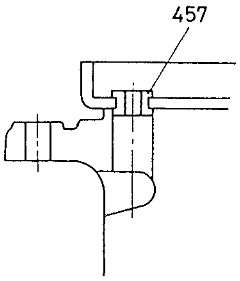
2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION


312
302
301
212
151
211
214
246
213
95
65
215
85
75
55
126
294
293
98
292
90
60
70
80
217
50
101
122
131
97
111
125
PORT 2, 4
PORT 5
PORT 1, 3
295



HYDRAULIC SYMBOLS



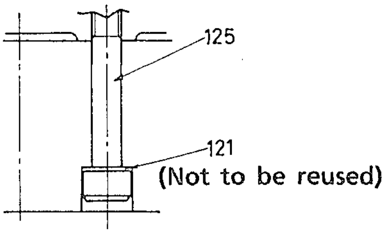

125
121
(Not to be reused)

Fig. 3 Cross-sectional view of pilot valve

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
50	SPOOL (For port 1,3)	2	101	VALVE BODY	1	215	WASHER	8
55	SPOOL (For port 2,4)	2	111	PLATE	1	217	WASHER	4
60	SPRING SEAT (For port 1,3)	2	121	SEAL WASHER	2	246	SPRING	4
65	SPRING SEAT (For port 2,4)	2	122	O RING	1	292	BALL	3
70	SPRING (For port 1,3)	2	125	CAPSCREW	2	293	PLUG	3
75	SPRING (For port 2,4)	2	126	SPRING PIN	1	294	O RING	3
80	SPRING (For port 1,3)	2	131	BUSHING	1	295	PLUG	2
85	SPRING (For port 2,4)	2	151	PLATE	1	301	JOINT	1
90	SPRING SEAT (For port 1,3)	2	211	PLUG	4	302	PLATE	1
95	SPRING SEAT (For port 2,4)	2	212	ROD	4	312	NUT	1
97	SEAT (All length 27.7 mm(1.09 in))	1	213	SEAL	4	457	BUSHING	1
98	SEAT (All length 30.7 mm(1.21 in))	2	214	O RING	4			

2.2 FUNCTION

(1) Pilot valve handle in neutral position (See Fig. 4)

In this case, the force of the secondary pressure setting spring (85) that determines the output pressure of the pilot valve is not transmitted to the spool (55). Accordingly, the spool is pushed up by the return spring (75), permitting the output 2,4 to connect with the tank port T. This makes the output pressure equal to the tank pressure.

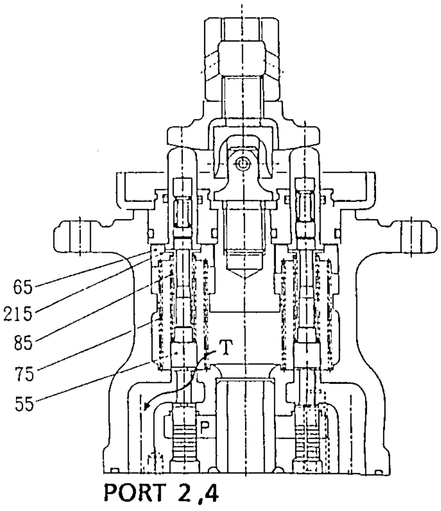


Fig. 4 Pilot valve handle in neutral position

(2) When the pilot valve handle is inclined (See Fig. 5)

When the handle is inclined and the push rod (212) strokes, the spool (55) moves downward to make the port P to connect with the port 2,4, with the result that the oil of the pilot pump runs out to the port 2,4 to produce a pressure.

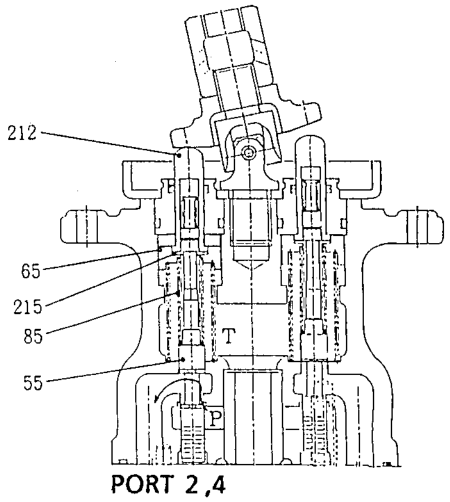


Fig. 5 When the pilot valve handle is inclined

(3) The pilot valve handle being held (See Fig. 6)

When the handle is inclined till the pressure of the port 2,4 rises to an oil pressure corresponding to the set spring force, the hydraulic pressure is balanced with the spring (85) force, and when the pressure of the port 1 rises above a set pressure, the port 2,4 and the port P are closed and the port T are opened. When the pressure of the port 1 falls below a set pressure, the port 1 and the port P are caused to open and the port 1 and the port T are caused to colse, thus holding the second pressure constant.

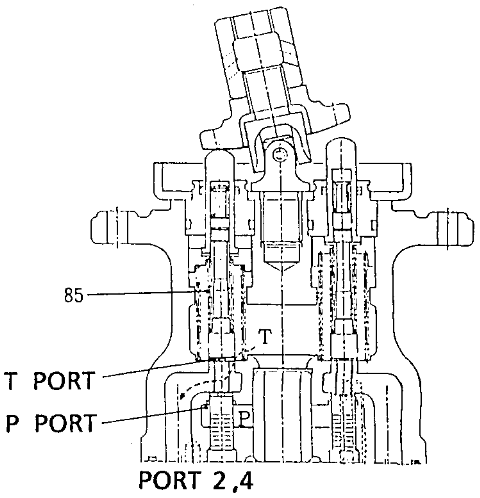


Fig. 6 The handle being held (when the secondary pressure is higher than a set pressure)

(4) High pressure selector valve. (See Fig. 3)

Valve body (101) is provided with plate (111) and the bottom surface of the plate (111) has ports P, T, 1, 2, 3, 4, and 5.
Port 5 is a high pressure selecting port that selects the maximum pressure of ports 1, 2, 3, and 4.

3 DISASSEMBLY AND ASSEMBLY

3.1 TOOLS

Tools necessary for disassembly and assembly are listed in Table 2.

3.2 REMINDERS ON DISASSEMBLY AND ASSEMBLY

1) Dust is extremely detrimental to hydraulic components.
   For this reason, exercise sufficient care to prevent entry of dust when handling hydraulic components.
   Take dust preventive measures even for partial disassembly.
2) Handle the moving parts with sufficient care.
   In case a slight scratch is made on the moving surface, recondition it or replace the associated part.
3) Use sufficient care so as not to damage the gasket surfaces and sliding surfaces of seals such as O rings.
   Otherwise, oil leaks may be caused.

3.3 DISASSEMBLY

1) Remove the handle lever ass'y, boots and lead wires from valve body (101). (See Fig.7.)
2) Fix the pilot valve to a vise, using copper pieces (or lead pieces).
3) Put a wrench in the width across the opposing flats of the plate (302) and turn the disk counterclockwise till joint (301) gets loosened.
4) Remove the operating part of the handle (301, 302, 312) from the valve body (101).
5) Remove plate (151).
6) Remove plug (211) from valve body (101), using a flatbladed screwdriver.

☞ When removing the plug, prevent the plug from being damaged by uneven loading, utilizing the peripheral groove in the plug (211).

⚠ Keep in mind that springs (70,75,80,85) may pop out by the spring action when the plug (211) is drawn out.

7) Remove push rod(212) and spring seats (90, 95).
8) Separate the spool ass'y from valve body (101).

☞ Record the relationship in position between the spool ass'y and the hole of valve body (101).

9) Take off springs (80,85).
10) Loosen capscrew (125), using an allen key wrench and remove port plate (111) from valve body (101).

Table 2

Tool Name	Size	Applicable Part No.
Allen key wrench	6mm(0.236 in)	125, 293
Wrench	22mm(0.866 in)	302, 312, 315
Cross-recessed screwdriver		411, 421, 431
Flat-bladed screw driver	Width 4~5mm (0.157~0.197 in) 2~3 mm (0.079~0.118 in)	211
Torque wrench	150~1,000kgf·cm (11~72 ft·lbs)	111, 125, 301, 312, 315
Allen key wrench	4mm (0.157 in)	295

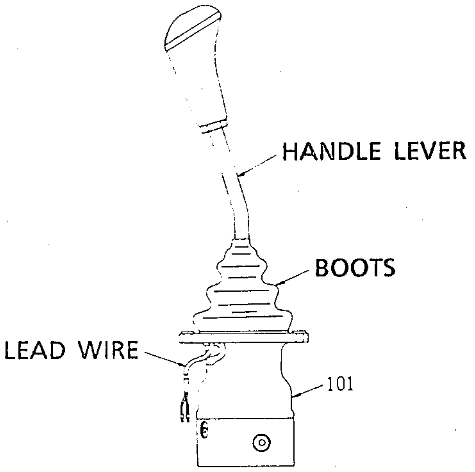


Fig. 7

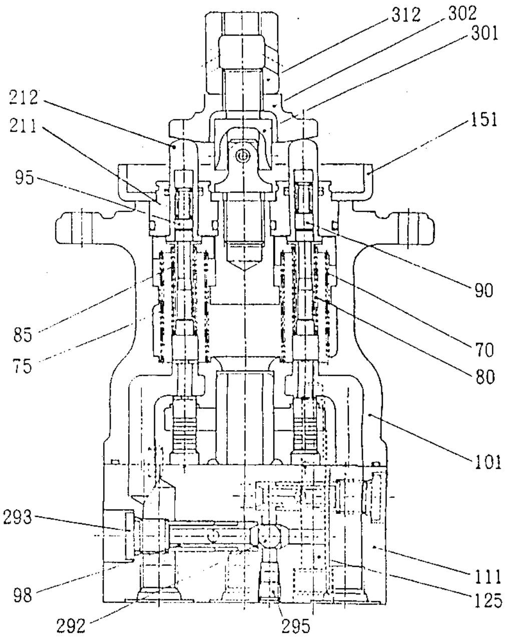


Fig. 8

11) Loosen plug (293), using an allen key wrench and take out seat (98) and steel ball (292).

12) Loosen plug (295), using an allen key wrench.

13) To dispart the spool ass'y place it on the bottom end of spools (50, 55) on a flat work bench, bring spring seats (60, 65) down and then remove two semi-circular washers 1 (215), using the tip of a small screw driver. (See Fig.9.)

☞ ● Use care not to damage the surface of spool (50, 55).
● Do not press down spring seat (60, 65) more than 6mm (0.236 in).

14) Seprate spool (50,55), spring seat (60,65), spring (80, 85) and washers 2 (217).

Handle them as an assembly till reassembly.

15) Loosen plate (302), adjust nut (312) and lock nut on the handle operating part, and dismantle joint (301). (See Fig. 10)

3.4 ASSEMBLY (See Fig. 10)

1) Before assembly, wash parts with clean oil and dry them with jet air, Avoid using rag as much as possible.

☞ Before assembly, always correct faults made during disassembly, clean parts, coat moving parts with oil and refit parts back in place.

2) Replace O rings with new ones.
Replace seal washers (121) with new ones, also.

3) Fit O rings (122) into valve body(101).

4) Place seal tape 1.5-2 turns around plug (295) and tighten port plate (111) to a specified torque.

5) Fix steel ball (292) and seat (98) to port plate (111) and tighten plug (293) to a specified torque.

☞ Tow kinds of seat lengths are available. Use care when fixing them.

6) Attach port plate (111) to valve body (101) with capscrew (125), and seal washer (121)

☞ Use care of the mounting position so spring pin (126) matches the hole in valve body (101).

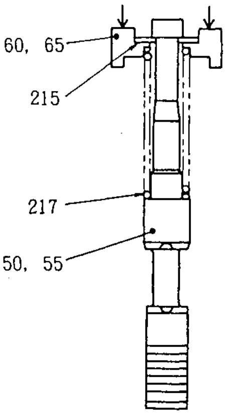


Fig. 9 Spool ass'y

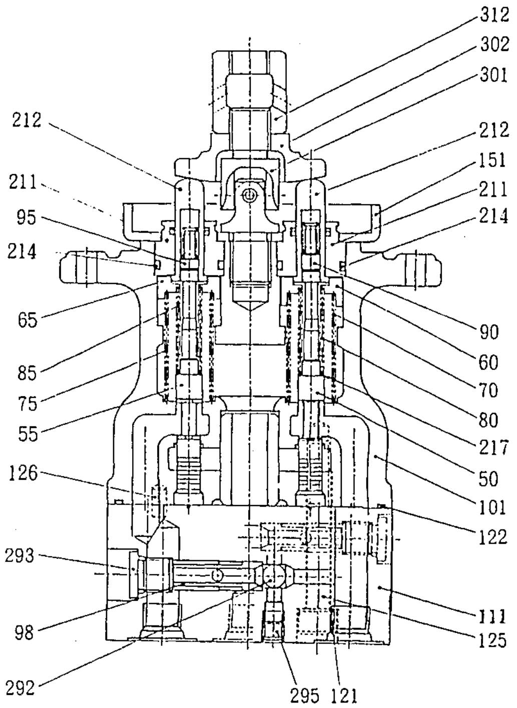


Fig. 10

7) Tighten copscrew (125) to a specified torque.

☞ Tighten two socket bolts by turns till a specified torque is reached.

8) Insert washer (217), spring (80,85) and spring seat (60,65) into spool (50,55) in that order. (See Fig. 9.)

9) Erect the lower end of spool (50,55) upright on a flat work benck, bring spring seat (60,65) down, and insert semicircular washers (215) into the top of spring seat (60,65) so two washers do not overlap each other.

☞ Do not bring down spring seat (60,65) more than 6 mm (0.236in).

10) Fit spring (70,75) into valve body (101)

☞ Refit it back in place.

11) Fit the pressure reducing valve assembly to valve body (101).

12) Fit seal (213) to plug (211) and then insert push rod (212) with spring seats (90, 95) into plug (211).(See Fig. 11)

☞ ◎ For the assembling direction of the lip of seal (213), see the figure 11.
◎ Coat push rod (212) with hydraulic oil.

13) Fit O ring (214) to plug (211).

14) Fit the plug assembly to valve body (101) (O ring stops by sliding resistance.)

15) Fit plate (151) to valve body (101).

16) Tighten joint (301) against valve body (101) to a specified torque.

17) Fit plate (302) to joint (301) and tighten adjust nut (312) to a specified torque till the disc comes in contact with four push rods (212).

☞ Tighten nut till the clearance between plate (302) and push rod (212) gets to 0.2mm (0.0079 in) or under.

18) Draw out the lead wire though the through hole of the valve body and then the side hole of the adjust nut located between 60 – 120° direction.

19) Fit bush (457) to plate (151) and put the lead through.

☞ Make the length of the lead wire necessary for operation sagging.

20) Apply heat resistant grease to the rotating part of the foints and the contact areas of the plate and push rod.

21) Attach the handle ass'y and boots to valve body (101).

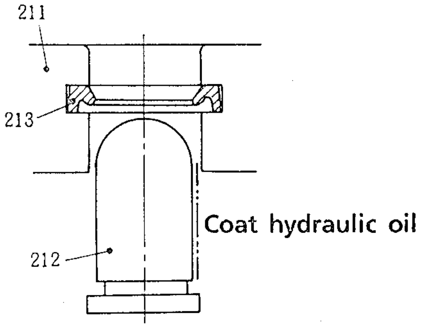


Fig. 11 Inserting the push rod

4. MAINTENANCE STANDARDS

4.1 PARTS REPLACEMENT STANDARD

1) Replace O rings and other seals at each disassembly and reassembly.
2) Replace worn parts if leaks increase to an ewtent that afects the associated system.
3) Replace spools having excessive wear on their moving areas.
4) Replace a push rod that is worn to 1mm (0.039 in) or over on its top end. (See Fig. 12.)
5) Replace operating handles and handle pins that have a gap of 2mm (0.079in) or over.
6) Replace such parts that develop abnormal sounds, hunting and drops in the primary pressure.

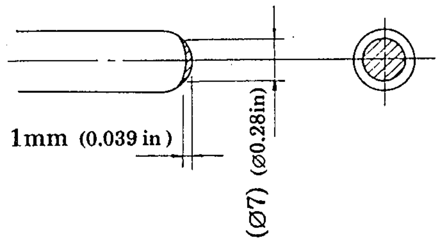


Fig. 12 Push rods

4.2 TIGHTENING TORQUE

Table 3 lists tightening torques.

Table 3

No.	Part Name	Size	Tightening Torque
111	Port plate	PF1/4	370kgf·cm (26.7ft·lbs)
125	Socket bolt	M8	300kgf·cm (21.7ft·lbs)
293	Plug	M12	100kgf·cm (7.2 ft·lbs)
295	Plug	NPTF 1/16	70kgf·cm (5.1 ft·lbs) (Seal lamp 1.5~2Roll)
301	Joint	M14	350kgf·cm (25.3ft·lbs)
312	Adjust nut	M14	500±3kgf·cm (36.1±0.2ft·lbs)

5. TROUBLESHOOTING

Trouble	Cause	Remedy
Secondary pressure does not rise.	1) Primary pressure is insufficient. 2) Springs (80, 85) are broken or fatigued. 3) Clearance between spool (50, 55) and valve body (101) is abnormally large. 4) Handle has a gap.	1) Secure primary pressure. 2) Replace with new ones. 3) Replace assembly. 4) Disassembly and reassembly or replace handle section.
Secondary pressure is unstable.	1) Sliding parts are caught. 2) Tank line pressure varies. 3) Air has mixed into pipeline.	1) Correct. 2) Bring pressure directly to oil tank. 3) Let air off.
Secondary pressure is high	1) Tank line pressure is high. 2) Sliding parts are caught.	1) Bring pressure directly to oil tank. 2) Correct.

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Book code No. S5 13045 7E①

SHOP MANUAL

PILOT VALVE

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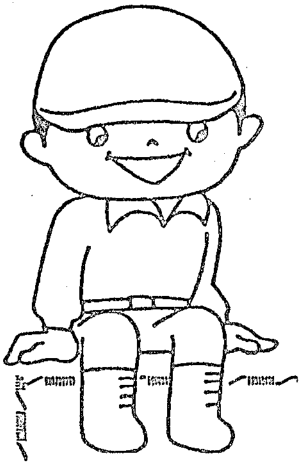

PREFACE

The pilot valve is a remote control valve of pressure reducing type that contains multiple pressure reducing valves in its casing to control secondary pressures.
The output pressure varies in proportion to the tilting of the control lever.
The secondary pilot pressure of the high pressure selector valve becomes an auto accel signal.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK100W	YE-1001~				
SK100	YW-2801~				
SK120	LP-5201~				
SK200	YN-6501~				
SK200LC	YQ-1101~				
SK220	LQ-2101~				
SK220LC	LL-1801~				
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	March, 1990	S5130457E K
First revison	June, 1990	S5130457E① K

1. SPECIFICATION

1.1 GENERAL VIEW

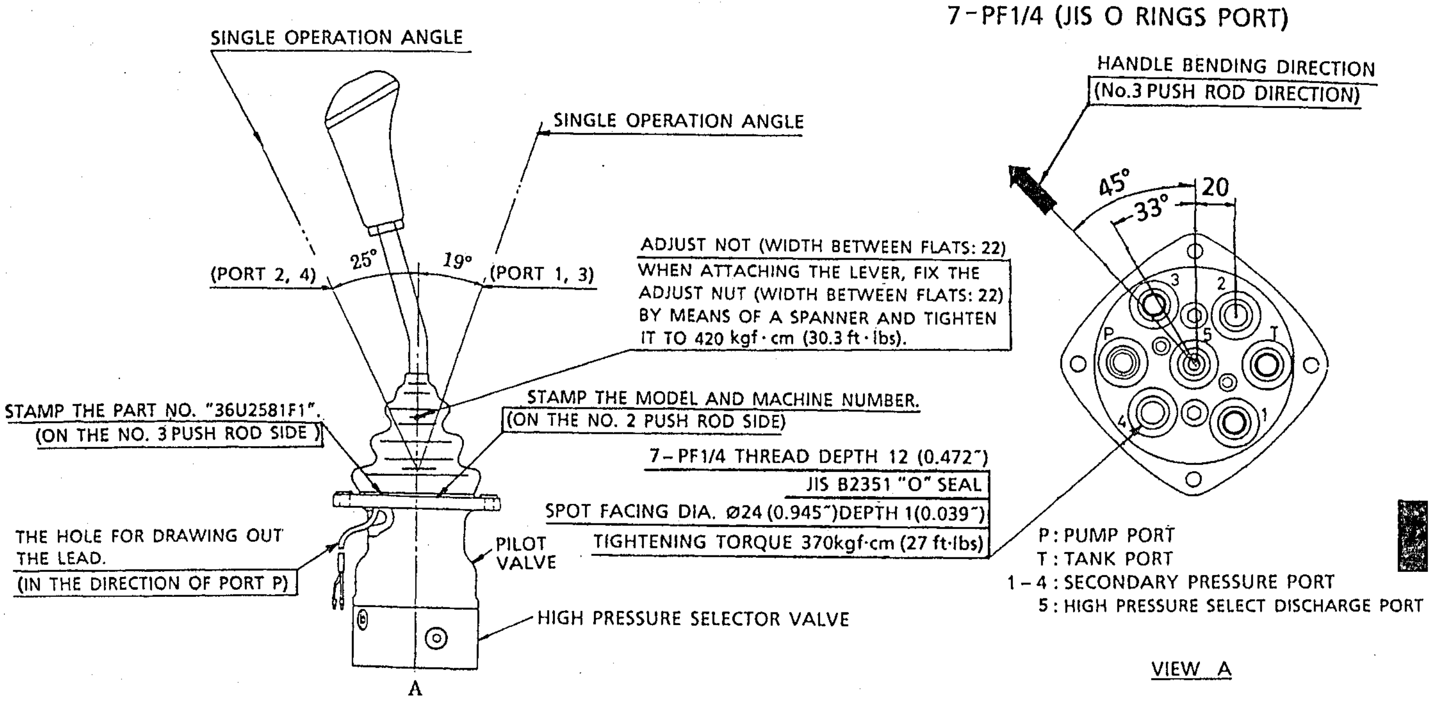
7-PF1/4 (JIS O RINGS PORT)
SINGLE OPERATION ANGLE
SINGLE OPERATION ANGLE
25°
19°
(PORT 2, 4)
(PORT 1, 3)
ADJUST NOT (WIDTH BETWEEN FLATS: 22)
WHEN ATTACHING THE LEVER, FIX THE ADJUST NUT (WIDTH BETWEEN FLATS: 22) BY MEANS OF A SPANNER AND TIGHTEN IT TO 420 kgf·cm (30.3 ft·lbs).
STAMP THE PART NO. "36U2581F1".
(ON THE NO. 3 PUSH ROD SIDE)
STAMP THE MODEL AND MACHINE NUMBER.
(ON THE NO. 2 PUSH ROD SIDE)
7-PF1/4 THREAD DEPTH 12 (0.472")
JIS B2351 "O" SEAL
SPOT FACING DIA. ø24 (0.945")DEPTH 1(0.039")
TIGHTENING TORQUE 370kgf·cm (27 ft·lbs)
THE HOLE FOR DRAWING OUT THE LEAD.
(IN THE DIRECTION OF PORT P)
PILOT VALVE
HIGH PRESSURE SELECTOR VALVE
A
HANDLE BENDING DIRECTION
(No.3 PUSH ROD DIRECTION)
45°
33°
20
3
2
P
5
T
4
1
P: PUMP PORT
T: TANK PORT
1 - 4 : SECONDARY PRESSURE PORT
5 : HIGH PRESSURE SELECT DISCHARGE PORT
VIEW A

Fig. 1 Outside view of pilot valve (TH40KC1090)

1.2 SPECIFICATION

Table 1

Primary pilot pressure	50 kgf/cm² (711 psi)
Operating torque	: 6kgf·m (43ft ·lbs) (Single operation, max.)
Operating angle	: 25° 19° (Ports 2, 4) (Ports 1, 3) (Single operation, max.)
Weight	: 6.4kg (14.1 lbs)

1.3 PERFORMANCE CHARACTERISTICS

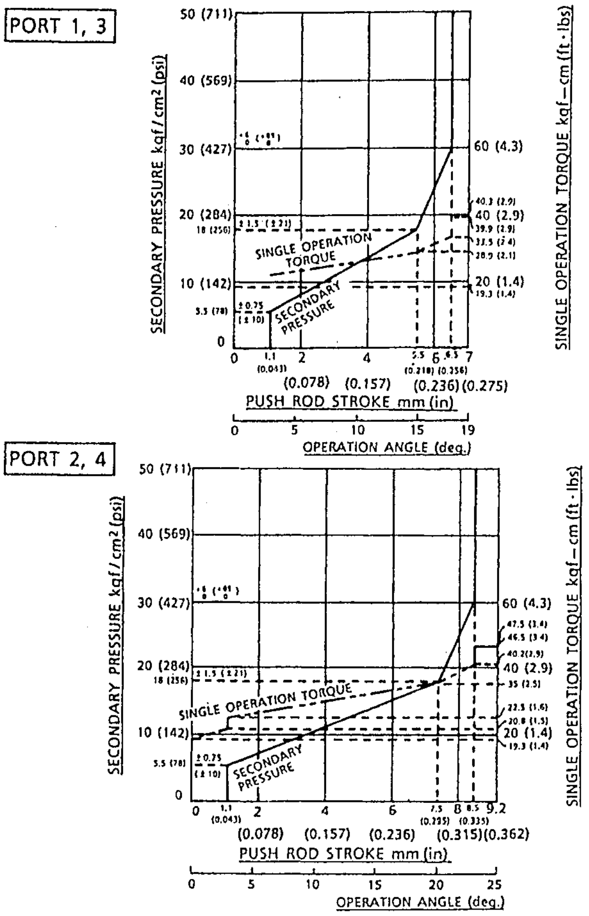

Fig. 2

2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION

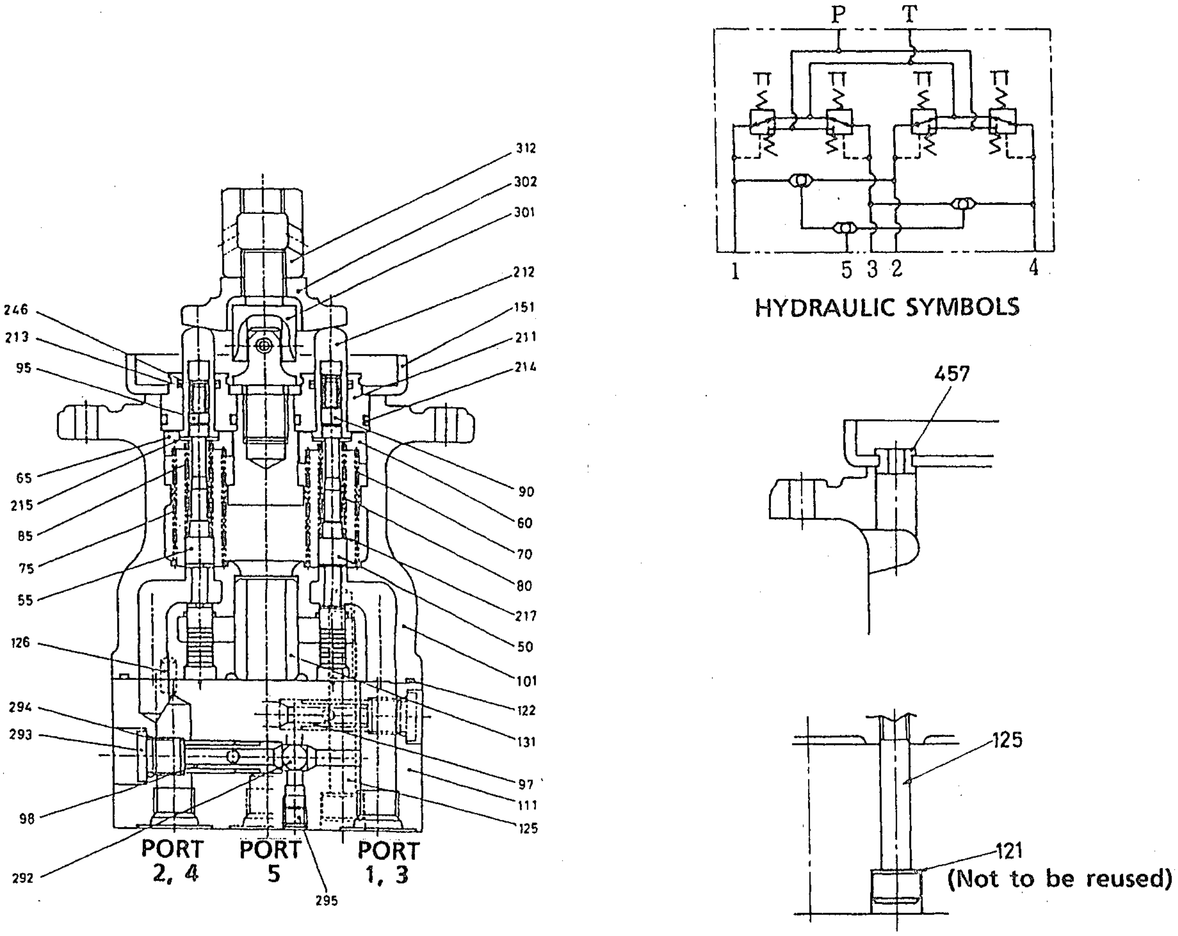
P
T
1
5
3
2
4
HYDRAULIC SYMBOLS
312
302
301
212
151
211
214
246
213
95
65
215
85
75
55
126
294
293
98
292
90
60
70
80
217
50
101
122
131
97
111
125
PORT 2, 4
PORT 5
PORT 1, 3
295
457
125
121
(Not to be reused)

Fig. 3 Cross-sectional view of pilot valve

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
50	SPOOL (For port 1,3)	2	101	VALVE BODY	1	215	WASHER	8
55	SPOOL (For port 2,4)	2	111	PLATE	1	217	WASHER	4
60	SPRING SEAT (For port 1,3)	2	121	SEAL WASHER	2	246	SPRING	4
65	SPRING SEAT (For port 2,4)	2	122	O RING	1	292	BALL	3
70	SPRING (For port 1,3)	2	125	CAPSCREW	2	293	PLUG	3
75	SPRING (For port 2,4)	2	126	SPRING PIN	1	294	O RING	3
80	SPRING (For port 1,3)	2	131	BUSHING	1	295	PLUG	2
85	SPRING (For port 2,4)	2	151	PLATE	1	301	JOINT	1
90	SPRING SEAT (For port 1,3)	2	211	PLUG	4	302	PLATE	1
95	SPRING SEAT (For port 2,4)	2	212	ROD	4	312	NUT	1
97	SEAT (All length 27.7 mm(1.09 in))	1	213	SEAL	4	457	BUSHING	1
98	SEAT (All length 30.7 mm(1.21 in))	2	214	O RING	4			

2.2 FUNCTION

(1) Pilot valve handle in neutral position (See Fig. 4)

In this case, the force of the secondary pressure setting spring (85) that determines the output pressure of the pilot valve is not transmitted to the spool (55). Accordingly, the spool is pushed up by the return spring (75), permitting the output 2,4 to connect with the tank port T. This makes the output pressure equal to the tank pressure.

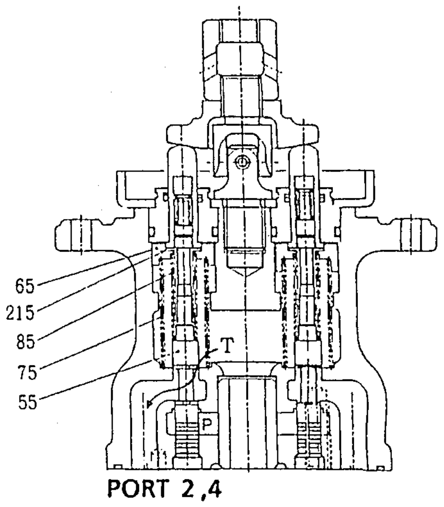

Fig. 4 Pilot valve handle in neutral position

(2) When the pilot valve handle is inclined (See Fig. 5)

When the handle is inclined and the push rod (212) strokes, the spool (55) moves downward to make the port P to connect with the port 2,4, with the result that the oil of the pilot pump runs out to the port 2,4 to produce a pressure.

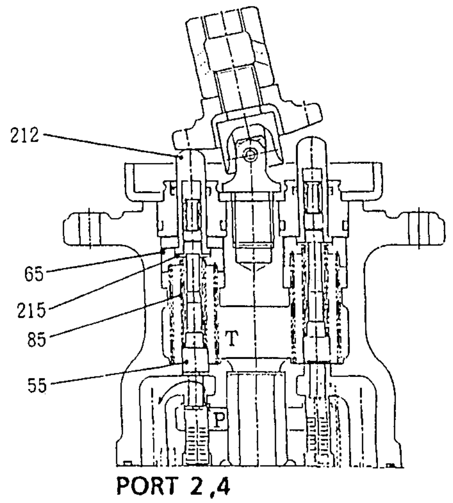

Fig. 5 When the pilot valve handle is inclined

(3) The pilot valve handle being held (See Fig. 6)

When the handle is inclined till the pressure of the port 2,4 rises to an oil pressure corresponding to the set spring force, the hydraulic pressure is balanced with the spring (85) force, and when the pressure of the port 1 rises above a set pressure, the port 2,4 and the port P are closed and the port T are opened. When the pressure of the port 1 falls below a set pressure, the port 1 and the port P are caused to open and the port 1 and the port T are caused to colse, thus holding the second pressure constant.

(4) High pressure selector valve. (See Fig. 3)

Valve body (101) is provided with plate (111) and the bottom surface of the plate (111) has ports P, T, 1, 2, 3, 4, and 5.
Port 5 is a high pressure selecting port that selects the maximum pressure of ports 1, 2, 3, and 4.

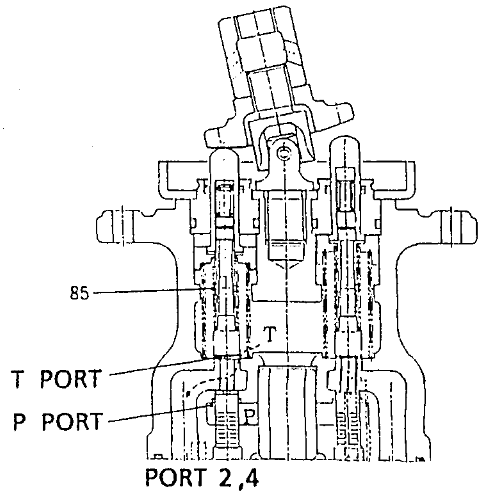

Fig. 6 The handle being held (when the secondary pressure is higher than a set pressure)

3 DISASSEMBLY AND ASSEMBLY

3.1 TOOLS

Tools necessary for disassembly and assembly are listed in Table 2.

3.2 REMINDERS ON DISASSEMBLY AND ASSEMBLY

1) Dust is extremely detrimental to hydraulic components.
   For this reason, exercise sufficient care to prevent entry of dust when handling hydraulic components.
   Take dust preventive measures even for partial disassembly.
2) Handle the moving parts with sufficient care. In case a slight scratch is made on the moving surface, recondition it or replace the associated part.
3) Use sufficient care so as not to damage the gasket surfaces and sliding surfaces of seals such as O rings.
   Otherwise, oil leaks may be caused.

3.3 DISASSEMBLY

1) Remove the handle lever ass'y, boots and lead wires from valve body (101). (See Fig.7.)
2) Fix the pilot valve to a vise, using copper pieces (or lead pieces).
3) Put a wrench in the width across the opposing flats of the plate (302) and turn the disk counterclockwise till joint (301) gets loosened.
4) Remove the operating part of the handle (301, 302, 312) from the valve body (101).
5) Remove plate (151).
6) Remove plug (211) from valve body (101), using a flatbladed screwdriver.

☞ When removing the plug, prevent the plug from being damaged by uneven loading, utilizing the peripheral groove in the plug (211).

⚠ Keep in mind that springs (70,75,80,85) may pop out by the spring action when the plug (211) is drawn out.

7) Remove push rod(212) and spring seats (90, 95).
8) Separate the spool ass'y from valve body (101).

☞ Record the relationship in position between the spool ass'y and the hole of valve body (101).

9) Take off springs (80,85).
10) Loosen capscrew (125), using an allen key wrench and remove port plate (111) from valve body (101).

Table 2

Tool Name	Size	Applicable Part No.
Allen key wrench	6mm(0.236 in)	125, 293
Wrench	22mm(0.866 in)	302, 312, 315
Cross-recessed screwdriver		411, 421, 431
Flat-bladed screw driver	Width 4~5mm (0.157~0.197 in) 2~3 mm (0.079~0.118 in)	211
Torque wrench	150~1,000kgf·cm (11~72 ft·lbs)	111, 125, 301, 312, 315
Allen key wrench	4mm (0.157 in)	295

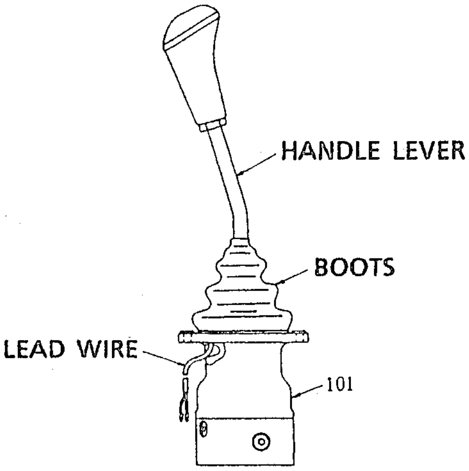

Fig. 7

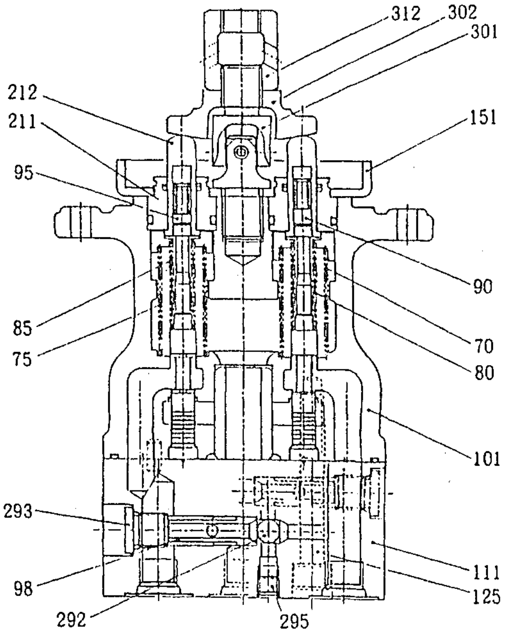

Fig. 8

11) Loosen plug (293), using an allen key wrench and take out seat (98) and steel ball (292).
12) Loosen plug (295), using an allen key wrench.
13) To dispart the spool ass'y place it on the bottom end of spools (50, 55) on a flat work bench, bring spring seats (60, 65) down and then remove two semi-circular washers 1 (215), using the tip of a small screw driver. (See Fig.9.)

☞ ● Use care not to damage the surface of spool (50, 55).
● Do not press down spring seat (60, 65) more than 6mm (0.236 in).

14) Seprate spool (50,55), spring seat (60,65), spring (80, 85) and washers 2 (217).

Handle them as an assembly till reassembly.

15) Loosen plate (302), adjust nut (312) and lock nut on the handle operating part, and dismantle joint (301). (See Fig. 10)

3.4 ASSEMBLY (See Fig. 10)

1) Before assembly, wash parts with clean oil and dry them with jet air, Avoid using rag as much as possible.

☞ Before assembly, always correct faults made during disassembly, clean parts, coat moving parts with oil and refit parts back in place.

2) Replace O rings with new ones.
Replace seal washers (121) with new ones, also.
3) Fit O rings (122) into valve body(101).
4) Place seal tape 1.5−2 turns around plug (295) and tighten port plate (111) to a specified torque.
5) Fix steel ball (292) and seat (98) to port plate (111) and tighten plug (293) to a specified torque.

☞ Tow kinds of seat lengths are available. Use care when fixing them.

6) Attach port plate (111) to valve body (101) with capscrew (125), and seal washer (121)

☞ Use care of the mounting position so spring pin (126) matches the hole in valve body (101).

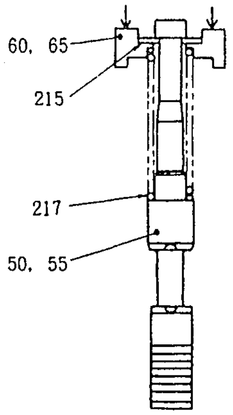

Fig. 9 Spool ass'y

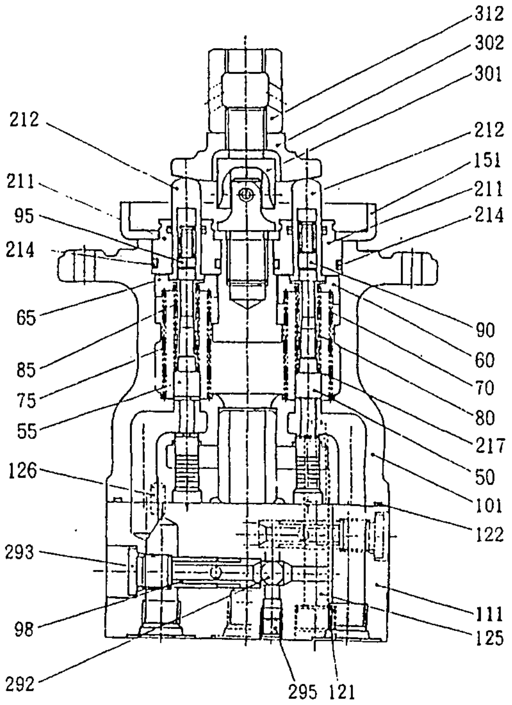

Fig. 10

7) Tighten copscrew (125) to a specified torque.

☞ Tighten two socket bolts by turns till a specified torque is reached.

8) Insert washer (217), spring (80,85) and spring seat (60,65) into spool (50,55) in that order. (See Fig. 9.)

9) Erect the lower end of spool (50,55) upright on a flat work benck, bring spring seat (60,65) down, and insert semicircular washers (215) into the top of spring seat (60,65) so two washers do not overlap each other.

☞ Do not bring down spring seat (60,65) more than 6 mm (0.236in).

10) Fit spring (70,75) into valve body (101)

☞ Refit it back in place.

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12) Fit seal (213) to plug (211) and then insert push rod (212) with spring seats (90, 95) into plug (211).(See Fig. 11)

☞ ○ For the assembling direction of the lip of seal (213), see the figure 11.
◎ Coat push rod (212) with hydraulic oil.

13) Fit O ring (214) to plug (211).

14) Fit the plug assembly to valve body (101) (O ring stops by sliding resistance.)

15) Fit plate (151) to valve body (101).

16) Tighten joint (301) against valve body (101) to a specified torque.

17) Fit plate (302) to joint (301) and tighten adjust nut (312) to a specified torque till the disc comes in contact with four push rods (212).

☞ Tighten nut till the clearance between plate (302) and push rod (212) gets to 0.2mm (0.0079 in) or under.

18) Draw out the lead wire though the through hole of the valve body and then the side hole of the adjust nut located between 60-120° direction.

19) Fit bush (457) to plate (151) and put the lead through.

☞ Make the length of the lead wire necessary for operation sagging.

20) Apply heat resistant grease to the rotating part of the foints and the contact areas of the plate and push rod.

21) Attach the handle ass'y and boots to valve body (101).

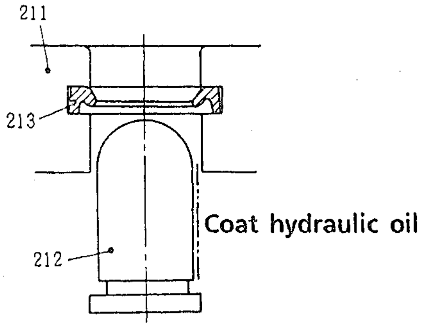

Fig. 11 Inserting the push rod

4. MAINTENANCE STANDARDS

4.1 PARTS REPLACEMENT STANDARD

1) Replace O rings and other seals at each disassembly and reassembly.
2) Replace worn parts if leaks increase to an ewtent that afects the associated system.
3) Replace spools having excessive wear on their moving areas.
4) Replace a push rod that is worn to 1mm (0.039 in) or over on its top end. (See Fig. 12.)
5) Replace operating handles and handle pins that have a gap of 2mm (0.079in) or over.
6) Replace such parts that develop abnormal sounds, hunting and drops in the primary pressure.

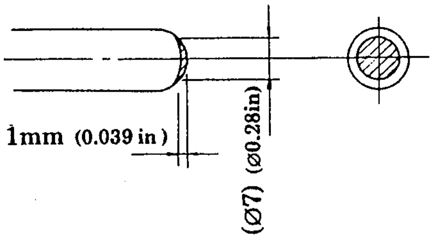

Fig. 12 Push rods

4.2 TIGHTENING TORQUE

Table 3 lists tightening torques.

Table 3

No.	Part Name	Size	Tightening Torque
111	Port plate	PF1/4	370kgf·cm (26.7ft·lbs)
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295	Plug	NPTF 1/16	70kgf·cm (5.1 ft·lbs) (Seal lamp 1.5~2Roll)
301	Joint	M14	350kgf·cm (25.3ft·lbs)
312	Adjust nut	M14	500±3kgf·cm (36.1±0.2ft·lbs)

5. TROUBLESHOOTING

Trouble	Cause	Remedy
Secondary pressure does not rise.	1) Primary pressure is insufficient. 2) Springs (80, 85) are broken or fatigued. 3) Clearance between spool (50, 55) and valve body (101) is abnormally large. 4) Handle has a gap.	1) Secure primary pressure. 2) Replace with new ones. 3) Replace assembly. 4) Disassembly and reassembly or replace handle section.
Secondary pressure is unstable.	1) Sliding parts are caught. 2) Tank line pressure varies. 3) Air has mixed into pipeline.	1) Correct. 2) Bring pressure directly to oil tank. 3) Let air off.
Secondary pressure is high	1) Tank line pressure is high. 2) Sliding parts are caught.	1) Bring pressure directly to oil tank. 2) Correct.

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KOBELCO

SHOP MANUAL

SWING CONTROL VALVE

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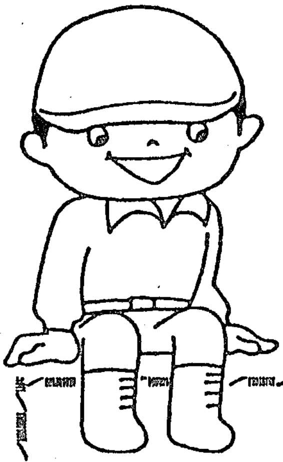


PREFACE

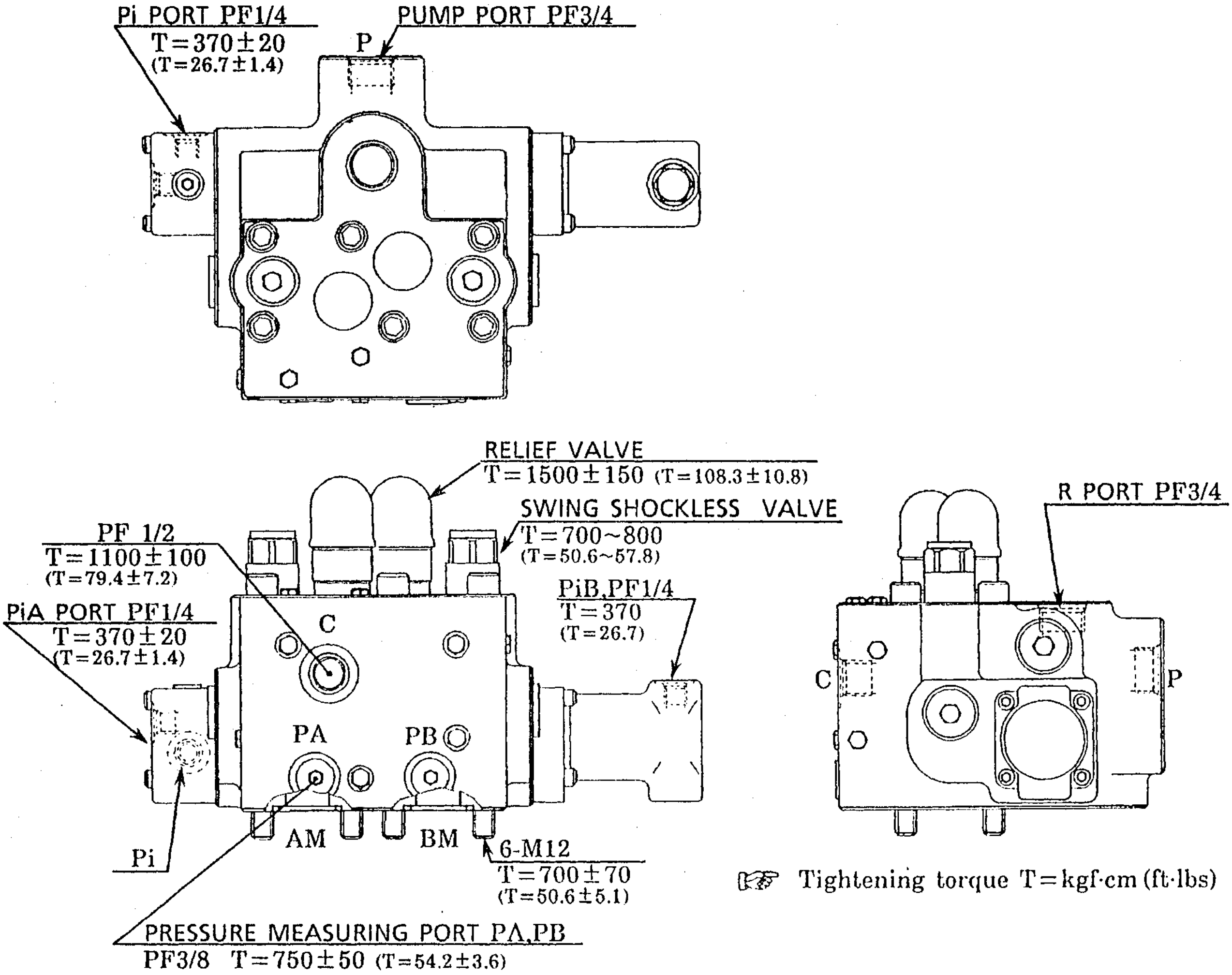
The swing control valve KSC series is direct-connected to the swing motor and controls smoothly the swing body having large inertial force according to external pilot pressure signals. The valve is provided with such functions as control of rotating direction, acceleration / deceleration, anti-cavitation, hold of a stop position and prevention of swing-back.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK200	YN-6501~	SPEC. 1			
SK200-LC	YQ-1101~	SPEC. 1			
SK60	LQ-11001~	SPEC. 2			

Revision	Date of Issue	Remarks
First edition	March, 1990	S5130666E K
First revison	June, 1990	S5130666E① K

1. SPECIFICATION

1.1 GENERAL VIEW


Pi PORT PF1/4
T=370±20
(T=26.7±1.4)
PUMP PORT PF3/4
P
RELIEF VALVE
T=1500±150 (T=108.3±10.8)
SWING SHOCKLESS VALVE
T=700~800
(T=50.6~57.8)
PF 1/2
T=1100±100
(T=79.4±7.2)
PiA PORT PF1/4
T=370±20
(T=26.7±1.4)
PiB,PF1/4
T=370
(T=26.7)
C
PA
PB
Pi
AM
BM
6-M12
T=700±70
(T=50.6±5.1)
PRESSURE MEASURING PORT PA,PB
PF3/8 T=750±50 (T=54.2±3.6)
R PORT PF3/4
C
P

☞ Tightening torque T=kgf·cm (ft·lbs)

Fig. 1 Outside view of control valve

1.2 PRINCIPAL PARTICULARS

Table 1

SPECIFICATION		SPECIFICATION 1	SPECIFICATION 1
Model		KSC15R-2.2SR3/250/150-205	KSC15R-2.2SR0/175/75-204B
Max. working pressure		315kgf/cm² (4480psi)	←
Rated flow		240ℓ/min (63.4gal/min)	←
Set pressure of relief valve		Effective pressure 250kgf/cm² (3560psi) at 150ℓ/min (39.6gal/min) back pressure 4kgf/cm² (56.9psi)	Effective pressure 175kgf/cm² (2490psi) at 75ℓ/min (19.8gal/min) back pressure 4kgf/cm² (56.9psi)
Cracking pressure for check valve.	Boost check valve	6.7kgf/cm² (95.3psi)	5kgf/cm² (71psi)
	Holding check valve	0.1kgf/cm² (1.4psi)	←
	Anti-cavitation check valve	0.1kgf/cm² (1.4psi)	←
Weight		20kg (44 lbs)	←

2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION

Table 2

No.	NAME	Q'ty
101	CASING	1
151	PLUG	1
152	PLUG	1
153	PLUG	1
161	O RING	1
162	O RING	2
163	O RING	2
164	O RING	2
165	O RING	1
166	O RING	1
171	SOCKET BOLT	6
201	SPRING COVER	1
202	VALVE SHUTTLE COVER	1
211	BALL	1
231	SEAT	1
251	PLUG	1
254	PLUG	8
261	O RING	1
263	O RING	8
271	SOCKET BOLT	2
272	SOCKET BOLT	2
301	SPOOL	1
321	SPRING	1
331	SPRING SEAT	2
332	SPACER BOLT	1
333	STOPPER	1
511	POPPET1	3
512	POPPET2(BOOST)	2
521	SPRING1	3
522	SPRING2	2
551	PLUG	5
561	O RING	5
601	RELIEF VALVE	2
602	SWING-SHOCKLESS VALVE	2

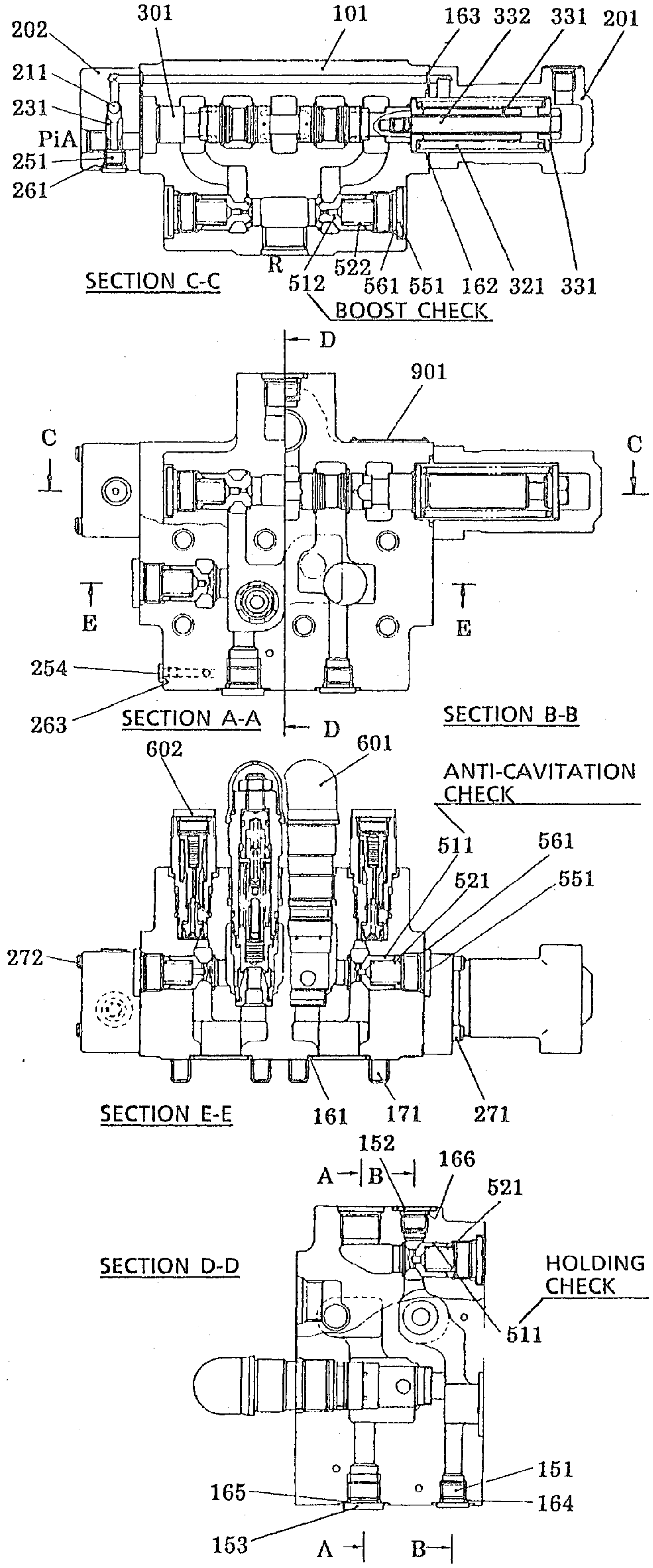

202
301
101
163 332 331 201
211
231
PiA
251
261
SECTION C-C
R
522
512
561 551 162 321 331
BOOST CHECK
D
901
C
C
E
E
254
263
SECTION A-A
D
SECTION B-B
602
601
ANTI-CAVITATION CHECK
511
561
521
551
272
SECTION E-E
161
171
271
152
A
B
166
521
SECTION D-D
HOLDING CHECK
511
151
165
164
153
A
B

Fig. 2 Cross-sectional view of control valve

(1) General

The swing control valve supplies hydraulic oil to the hydraulic motors. The direction control spool (301) is usually held in the neutral position in casing (101) having a boost oil feed port, by the action of spring (321). The casing (101) contains check valves (511.512) that perform the functions described below:

1) Holding check valve (511)
2) Anti-cavitation check valve (511)
3) Boost check valve (512)

Between mounting bolts are arranged cartridges for the relief valves (601) independently to cross over the valve structure via the anti-cavitation check valve.

A ball type shuttle valve is fitted in cover (202) on the opposite side of spring cover (201).

(2) Direction control spool and holding check valve sections.

The spool (301) that controls and feed the oil supplied by the hydraulic pumps according to the hydraulic motor making regular and reverse rotation are held neutral in casing (101) by springs (321), fitted with spring seats (331) and spacer bolt (332) on one end of the spools.

Shuttle cover (202) on another end of the spool has a built-in shuttle valve that selects the highest pilot pressure.

Furthermore, a holding check valve (511) is built in casing (101) to prevent back flow from the hydraulic motor when the spool makes a minimal stroke and the supply pressure of the hydraulic pump is low.

(3) Relief valve and anti-cavitation check valve sections

Two relief valves (601) are arranged independently by cartridges. The primary side is so designed as to connect with the hydrauli motor port, whereas the secondary side is so devised as to connect with the boost check valve's inlet port. The secondary sides of the two relief valves (601) are through to each other, each being connected with a hydraulic port by way of an anti-cavitation check valve (511). Thus the hydraulic pressure acts in a crossover direction.

Relief valve (601) has a function of relaxing low or high pressure.

So that it can vary the set pressure by adjusting the screw.

(4) Boost check valve and anti-cavitation check valve sections

A boost check valve (512) is provided immediately before the port leading to the hydraulic tank to supplyse the feed pressure that is required to allow the hydraulic motor to perform a pumping action.

The boost pressure acts on the feed port of the hydraulic motor via anti-cavitation check.

In case the oil supplied by the hydraulic pumps does not run through the boost check valve when the spools are in neutral, like the hydraulic system of this machine, separate boost oil must be fed from port C.

(5) Construction of relief valve

The brake valve contains two cartridge type relief valves that stop the regular and reverse rotations of the hydraulic motor. The relief valves relieve high pressure at start or at stop of swing motion and can control the relief pressure in two steps, high and low, in order to insure smooth operation.

(6) Swing-shockless valve section

Two swing-shockless valves are arranged independently.

2.2 FUNCTION

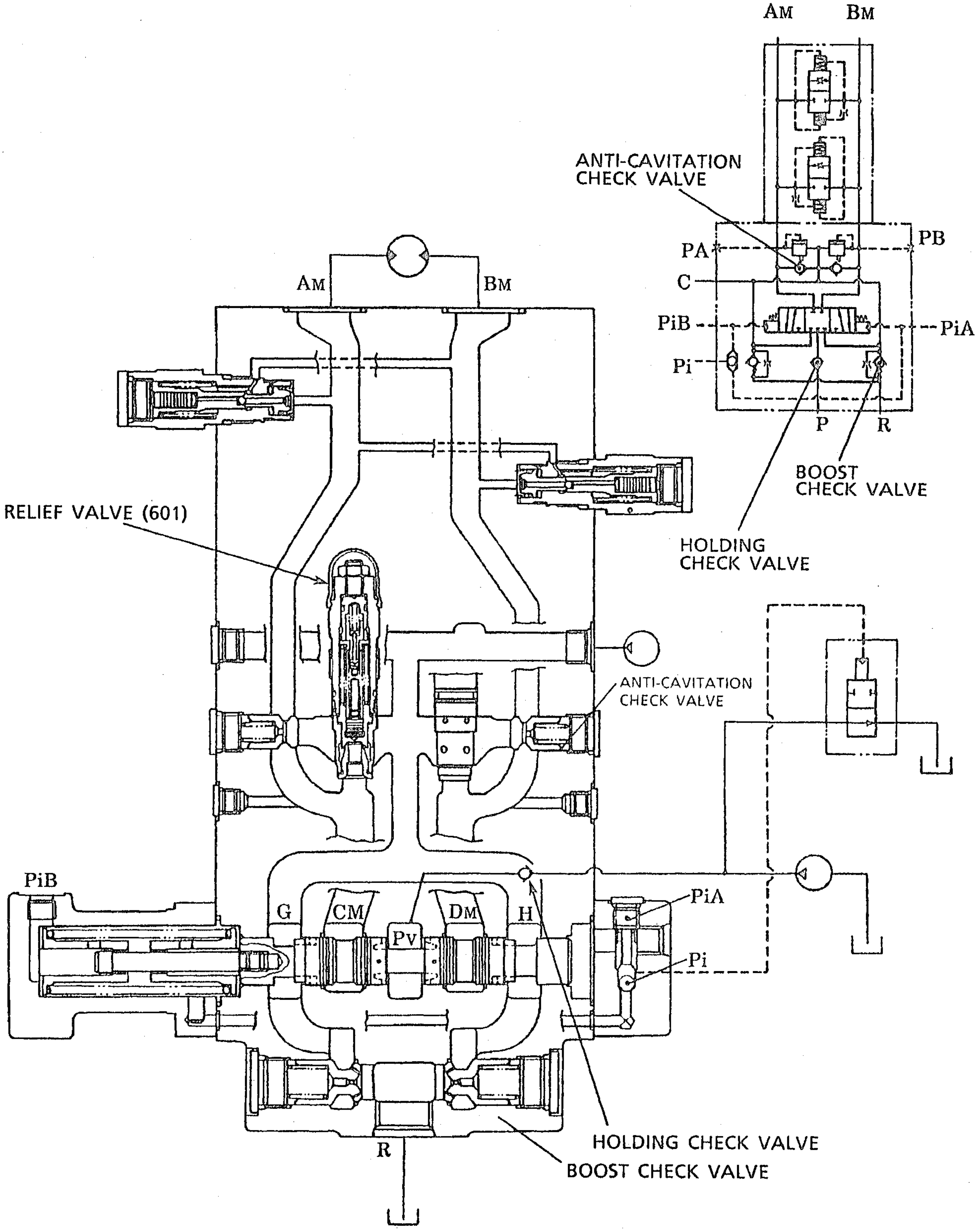

AM
BM
ANTI-CAVITATION CHECK VALVE
PA
PB
C
PiB
PiA
Pi
P
R
BOOST CHECK VALVE
HOLDING CHECK VALVE
RELIEF VALVE (601)
AM
BM
ANTI-CAVITATION CHECK VALVE
PiB
G
CM
Pv
DM
H
PiA
Pi
R
HOLDING CHECK VALVE
BOOST CHECK VALVE

Fig. 3 KSC15R Functional explanation

(1) Hold Condition

The direction control spool (301) lies in the neutral position by the action of springs (321). Since port PiA is held at the tank pressure as ports PiA, and PiB are also kept to the tank pressure. This brings the cut valve built in the main control valve to a neutral position which in turn makes the discharge oil from the hydraulic pumps in an unloaded condition. The boost oil supplied from port C passes through C,L and the boost check valve and returns to the hydraulic tank from port R. Accordingly, port L receives a pressure deter-mined by the boost check valve.

Ports AM and BM leading to the hydraulic motor are blocked by the anti-cavitation check valve, relief valve (601) and spools (301), at CM and DM, so that the hydraulic motor keeps its standstill position even if an external force acts on the hydraulic motor, pressure builds up at ports AM or BM.

The hydraulic motor then rotates only slightly due to internal leaks from the hydraulic motor and spools (301), attempting to develop a cavitation on the low pressure side of the closed circuit. The anti-cavitation check valve functions only to prevent cavitation, forms a passage C (R) → L →AM (BM) and supplies an amount of oil equal to the leakage to the closed circuit.

(2) At Operation

If pilot pressure acts upon the pilot port PiA (or PiB), the spool (301) moves rightwards (or leftwards) as it bents spring (321). Meanwhile the port Pi receives pilot pressure.

The pressure occurring port Pi shifts the cut valve spool built in the main control valve to choke the path of the hydraulic pump's discharged oil to the hydraulic tank. As the result, the discharge oil pressure of the pump fed to port P tends to rise. In the meantime, opening the passages PV →CM → AM (BV → DM → BM) and PV → DM → H (AM →CM →G) causes the hydraulic pump's discharge oil to be fed to the hydraulic motor. The oil discharged from the hydraulic motor returns to the hydraulic oil tank and attempts to turn the hydraulic motor.

Where the hydraulic motor has a large inertial load, the revolution of the hydraulic motor does not increase suddenly and the pressure at port AM (BM) rises. Thereupon, relief valve (601) operates and the surplus oil returns to the hydraulic tank by way of the route AM → L → R (BM → L → R). In this way. the hydraulic motor mounts its revolution gradually. relieving oil till it rotates at full speed.

If the hydraulic motor tries to rotate beyond the pump's oil feed rate due to external force, the pressure at port AM (BM) falls, which in turn actuates the anti-cavitation check valve. This causes the hydraulic oil to be supplied by way of L → AM (BM) to prevent the hydraulic motor from developing cavitation.

(3) At Stop Operation

If the pressure of pilot PiA (or PiB) falls, spools (301) move in the neutral direction by the action of springs (321). As the result, the area of the passage DM → G decreases, and if the hydraulic motor is in rotation, it tries to keep its rotation by the inertial force of the existing load. The result is that the hydraulic motor makes pumping action to discharge hydraulic oil to port BM so that pressure of port BM increases. This eventually gives the hydraulic motor a braking pressure.

When spools (301) move in the neutral direction, the pressure at port BM rises to actuate relief valve (601). Thus the oil from the hydraulic motor returns through the route BM, relief valve, L, anti-cavitation check valve and AM. Here, the pressure at position L is held to a level as determined by the operating pressure of the boost check valve, with the result that the hydraulic motor is subject to a braking torque corresponding to the set pressure of the relief valve.

Thus the hydraulic motor decelerates itself gradually to a complete standstill.

On that occasion, the pressure at port Pi falls as well, which in turn moves the cut valve spool built in the main control valve in the neutral direction.

This then causes the hydraulic pump's discharge pressure to fall and brings the hydraulic motor to an unloaded condition.

(4) Relief Valve

1) Construction

Table 3

No.	PART NAME	Q'ty	No.	PART NAME	Q'ty
101.	BODY	1	323.	SPRING	1
201.	PLUG	1	331.	SEAT SPRING	1
261.	O-RING	1	341.	SEAT	1
262.	RING BACK UP	1	342.	BUSHING	1
291.	RING	1	343.	SEAT SPRING	1
301.	PLUNGER	1	361.	O-RING	1
302.	PISTON	1	362.	RING BACK UP	1
303.	PISTON	1	471.	SETSCREW	1
311.	BALL	1	473.	LOCKNUT	1
321.	SPRING	1	851.	CAP	1
322.	SPRING	1			

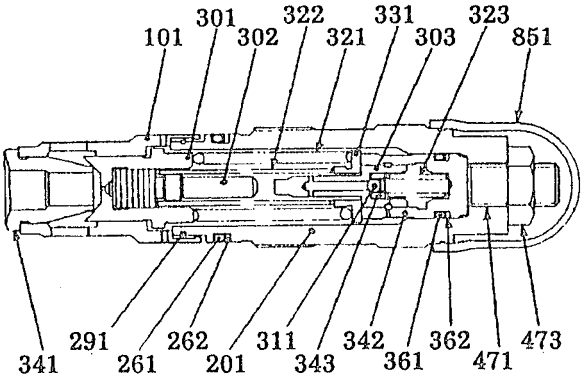

101
301
302
322
321
331
303
323
851
341
291
261
262
201
311
343
342
361
362
471
473

Fig. 4 Relief valve

2) Function of relief valve

Fig.5 illustrates how the pressure acting on the relief valve is related to its rising process. Here is given the function, relief to the figure below.

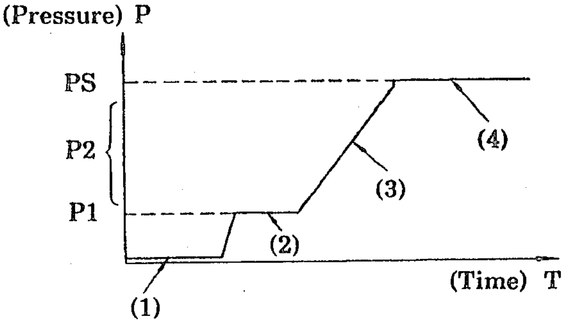


Fig. 5 Control pressure of relief valve

a. Function when P=P1 (See Fig. 6.)
When the pressure at port (P) rises, it enters the chamber (g) through restriction (f) and presses piston (302) which in turn presses spring (322) to shift piston (302) rightwards, so as to hold the pressure in chamber (g) low. Thus the plunger (301) functions to get P=P1.

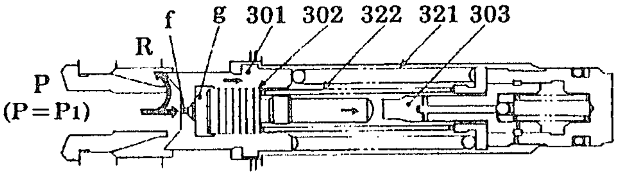

f
g
301
302
322
321
303
R
P
(P=P1)

Fig. 6

b. Function when P=P2 (See Fig. 7.)
When piston (302) hits piston (303), they move rightward together. As the result, restrictor (h) is closed, bringing chamber (j) to a confined state. The pressure rising process is $P=P_2$.

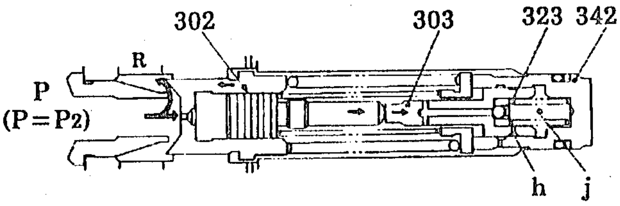

302
303
323
342
R
P
(P=P2)
h
j

Fig. 7

c. Function when P=PS (See Fig. 8.)
A state P=PS is attained the moment piston (303) strikes the bottom of bush (342).

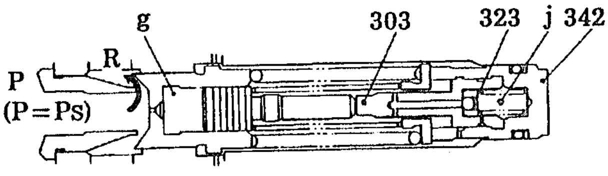

g
303
323
j
342
R
P
(P=Ps)

Fig. 8

(5) Swing-shockless valve

1) Construction

Table. 4

No.	PART NAME	Q'ty	No.	PART NAME	Q'ty
161	O-RING	1	312	PISTON	1
162	RARE FLEON RING	1	313	SEAT	1
163	RING BACK UP	1	315	BALL	1
251	PLUG	1	321	SPRING	1
261	O-RING	1	322	SPRING	1
311	PLUNGER	1	371	SHIM	1

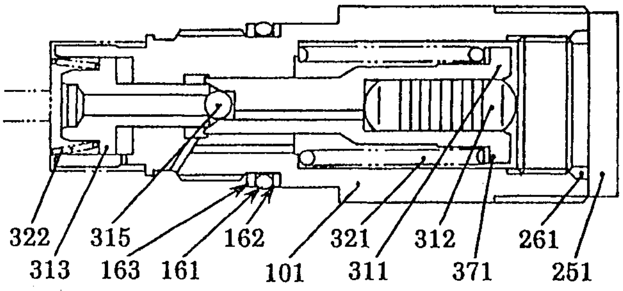


Fig. 9 swing-shockless valve

2) Function of the swing-shockless valve

Fig. 9 shows the relationship between pressure acting upon the swing-shockless valve and its rising process. The functions of it is explained below :

a. Function of P=PS (See Fig. 11.)

Now, let us think about the condition at which braking pressure occurs on the port Am side. The port Am pressure is induced to chamber n through path 1, the shaft hole of seat (313) and path m in plunger (311). When pressure P rises above a set point of spring (321), plunger (311) moves leftwards as it bends spring (321).

In the meantime the seat (313), pushed by plunger (311), moves leftwards as it bends spring (322).

b. Function of P<PS (See Fig. 12.)

When swing action stops (at Y point in Fig. 10), the braking pressure begins to fall. At P<PS, the plunger (311) moves back to the right by the action of spring (321). The seat (313) also moves to the right by the action of spring (322). However, since chamber (g) is provided with a damping function by chamber (g), seat (313) returns later than plunger (311), with the result that the seat t is detached. This causes the pressure to run in the order of l → t → r → K and form a path that connects the Am, Bm ports.

Consequently, ports Am and Bm are equally pressured, i. e. a condition at point Z in Fig. 10, theredy preventing the hydraulic motor from rever sing by pressure confined in the AM port.

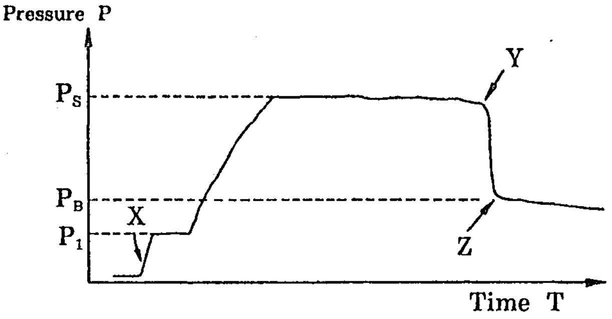


Fig.10 Control pressure of swing-shockless valve

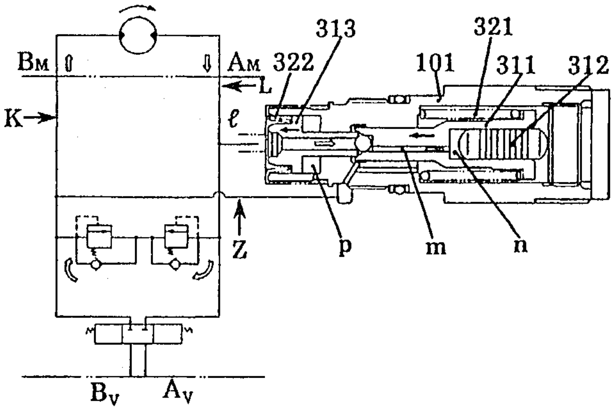


Fig. 11 Function of P=PS

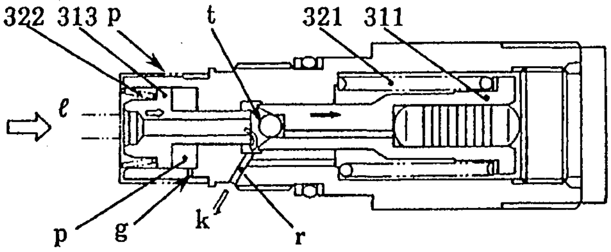


Fig. 12 Function of P<PS

3. DISASSEMBLY AND ASSEMBLY

3.1 GENERAL PRECAUTIONS

1) Because components are precision machined, a particularly clean place must be selected in performing disassembly and assembly.
2) When dismantling components from the machine, apply a cap to each port. Reconfirm before disassembly that caps are fitted completely and then clean the exterior of the assembly.
3) Select a work bench spacious enough to place components, and lay a clean paper or a rubber matress over it.
4) Exercise sufficient care so as not to allow dust, soil and sand in components when handling them.
5) Handle components with care so that they may not hit each other and fall down during operation.
6) Do not strike or pry up components too hard. Otherwise, it may bur or break components making assembly impossible. Note that such rough handling may cause oil leakage and deterioration in performance.
7) If components are left disassembled or halfdisassembled, they may develop rusting due to moisture and dust. Take rust preventive and dust preventive measures when suspending operation halfway for an unavoidable reason.

3.2 TOOLS

Table 5

Tool	Widthacross flats	No	Part name	Screw size
Hexagon key wrench	5mm (0.20″)	271 272	Socket bolt Socket bolt	M6
	6mm (0.24″)	251	Plug	M12
	8mm (0.31″)	151 332	Plug Spacer bolt	PF 3/8 M8
	10mm (0.39″)	171 153	Socket bolt Plug	M12 PF 1/2
	12mm (0.47″)	551	Plug	M24
Spanner	19mm (0.75″)	473 152 253	Relief valve locknut Plug Plug	M12 PF 1/4 PF 1/4
	22mm (0.87″)	602	Swing-shockless valve	M22
	27mm (1.06″)	601	Relief valve	M33
Torque wrench	100~2,000 kgf·cm (7.22~144 ft·lbs)			
Grease	Several grams			
Volatile rust preventive agent	1 pc			
Three-Bond	1305			
Loctite	#262			
Plastic mallet	1 pc			

3.3 DISASSEMBLY

☞ •The following gives only the operating pro-cedure. For details, refer to the construction drawings (Fig. 2,4 and 9).

•The numbers in parentheses after par names in the following instructions correspond to those in the construction drawings (Fig. 2,4 and 9).

(1) Wash the control valve with kerosene. Take off O rings (161) beforehand.

☞ Apply a plug to each port to prevent intrusion of dust and other foreign matter before washing with kerosene.

(2) Disassembling the spool section

1) Loosen plug (251).
2) Remove socket bolt (272).
3) Dismantle shuttle valve cover (202).
4) Take off plug (251).
5) Draw out seat (231). Then ball (211) may be taken out.

☞ Use care so as not to lose ball (211).

6) Remove socket bolt (271).
7) Dismantle spring cover (201).
8) Draw out the assembly consisting of spool (301), spring (321), spring seat (331) and spacer bolt (332).

☞ Draw out spool (301) straight in its axial direction.

9) Hold the two opposing flats of spool (301) in a lead plate attached vise and then remove spacer bolt (332).

☞ •The thread face of spacer bolt (332) is coated with adhesive agent, therefore, the bolt may be hard to come off.

•Use care so as not to damage the outside of spool (301).

•Take care as the spring may pop up when the screw coming off.

10) Remove spring seat (331) and spring (321).
11) Remove O rings (162, 163) from casing (101).

(3) Disassembling holding check valve

1) Remove plug (551).
2) Draw out spring (521) and poppet 1 (511).

(4) Draw out spring (521) and poppet 1 (511) of the anti-cavitation check valve, in the same way as above-mentioned.

(5) Draw out spring (522) and poppet 2 (512) of boost check valve, in the same manner as above-mentioned.

☞ The components of the holding check valve, the anti-cavitation check valve and the boost check valve are alike with each other. Use full care so as not to intermingle with one another.

(6) Remove plug (151).

(7) Remove plug (153).

(8) Remove plug (152).

(9) Loosen relief valve (601).

(10) Separate relief valve (601) from casing (101).

☞ Draw out relief valve (601) gently by positioning it on the side so that it may not get apart.

The seat may remain inside. Take it out so as not to damage the edge.

(11) Disassembling relief valve (See. Fig. 4)

1) Hold plug (201) and body (101) a little and fold them, pressing them against each other. Then C ring (291) comes off.

☞ If they are pressed too much, they can not be folded. C ring (291) will be easy to come off if its opening is directed outward.

2) Separate piston (302), plunger (301) and seat (341) from body (101).

☞ Seat (341) will be easy to come out if it is rotated when being drawn.

3) Draw out springs (321, 322) from plug (201).
4) Tightening setscrew (471) will make the assembly of bushing (342) and piston (303) come out of plug (201)

☞ Do not tighten setscrew (471) when pressure adjustment is impossible at reassembly.
Lightly tapping the assembly directing it downward will make it come out except the bushing.

5) Bushing (342) may be disassembled into spring (323), piston (303) and spring seat (343).

(12) Disassembling the swing-shockless valve (See Fig. 9.)
1) Separate swing-shockless valve (602) from casing (101).
2) Seat (313) comes off together if spring (322) is drawn out.

☞ If the valve is directed down, ball (315) falls down. Use care so the ball is not lost.

3) If plug (251) is taken off, the ass'y of plunger (311) can be drawn out.

☞ Exercise care so as not to drop piston (312).

3.4 AFTER DISASSEMBLY

(1) Clean all parts.
1) Put parts in a container filled with kerosene and wash them. (rough cleaning)

☞ ◎If dirty parts are washed in kerosene, they may be scratched. Keep parts immersed in kerosene till dirt and greasy matter get loose and afloat.
◎Use of dirty kerosene will damage parts and mar the performances of the parts. Control kerosene well to keep it clean at all times.

2) Put parts in a container filled with clean kerosene and rotate it slowly till they may be washed to the inside sufficiently. (finish cleaning)
3) Wipe off kerosene adhered to parts with clean rag.

☞ Do not use jet air to dry parts as it may damage or rust parts by dust and moisture contained in the jet air.

(2) Rust prevention of parts
Blow rust preventive medium to parts.

☞ Note that if parts are left in an as-washed condition, they may be rusted and will cease to display sufficient performances after assembly.

3.5 ASSEMBLY

☞ •This section provides operating procedures only. For further details, refer to construction drawings (Fig.2, 4 and 9).
•The numbers in parentheses after part names in the instructions correspond to those in construction drawings (Fig.2, 4 and 9).

3.5.1 PRECAUTIONS TO BE TAKEN IN ASSEMBLY

In general, assembly is the reverse order of disassembly, but notice the following precautions:

1) Before proceeding to assembly, remove metallic particles and foreign matter from parts and confirm that parts are free from burr and blow marks. If burr and blow marks are present, remove them with an oilstone.
2) Replace O rings, packing and backup rings with new ones as a rule.
3) When fitting O rings, packings and backup rings, use care not to damage them. (Coat them with a thin film of grease for smooth functioning.)
4) When fitting parts, use grease to prevent them from falling down.
5) Tighten socket bolts and plugs to the torques specified under Maintenance Standards to be mentioned later.
6) When assembly is complete, put a plug to each of the ports to prevent entry of dirt.

3.5.2 ASSEMBLY PROCEDURE

(1) Assembling relief valve

1) Fit ball (311), spring seat (343) and spring (323) to piston (303). Put the piston into bush (342) and then spring seat (331).

☞ •Coat ball (311) with grease, fit spring seat (343), and attach piston (303) as if it were covered from above.
•Direct piston (303) so spring (323) faces up, and take care so ball (311) may not come off from the seat hole.
•Confirm that spring (323) is set in the guide hole of bushing (342).

2) Fit the bushing assembly into plug (201).

☞ Lightly knock on the end face of piston (303) with a plastic mallet.

3) Fit seat (341), plunger (301) and piston (302) to body (101).
4) Fit springs (321,322) to plug (201) and set C ring (291), pressing plug (201) against body (101).

☞ Work will be facilitated if C ring (291) is bent a little, the opposite side of its opening is put in and then it is pushed in straight.

(2) Attach O ring (164,165,166) to plug (151,152, 153) and tighten it against casing (101) to the specified torque.

(3) Assembling boost check valve

1) Insert poppet 2 (512) and spring 2 (522) to casing (101).
2) Attach O ring (561) to plug (551) and tighten it to casing (101) to the specified torque.

(4) Assemble poppet 1 (511), spring 1 (521) and plug (551) into the anti-cavitation check valve, in the same manner as above-mentioned.

(5) Assemble poppet 1 (511), spring (521) and plug (551) into the holding check valve, in the same manner as above-mentioned.

(6) Screw relief valve (601) into casing (101).

☞ Direct casing (101) so relief valve (601) can be set in a horizontal position so as to prevent seat (231) from falling down.

(7) Tighten relief valve (601) to the specified torque, using a torque wrench.

(8) Fix swing-shockless valve (602) into casing (101).

☞ Tightening torque : 700~800kgf·cm (50.5 ~ 57.8 ft-lbs)

(9) Assembling spool section

1) Degrease the female thread area of M8 screw of spool (301) and hold its small diameter part in a vise in which lead plates are placed.
2) Coat the M8 male thread of spacer bolt (332) with Three Bond 1305. (Locktite #241)

☞ Apply Loctite over 4~5 threads with one thread at the tip left uncoated.

3) Fit spring seat (331) and spring (321) into spool (301), and tighten spacer bolt (332) (with its thread part decreased) to a specified torque.

☞ After tightening, leave it for a few hours.

4) Attach O rings (162,163) to casing (101).
5) Insert the spool assembly into casing (101).

☞ ●Put in the spool assembly straight, watching its mounting direction.
●Assembly will be facilitated if a small amount of hydraulic oil is applied to the outside diameter of the spool.

6) Fix spring cover (201) to casing (101) by means of socket bolt (271).

☞ Align the pilot path in spring cover (201) to the hole in casing (101).

7) Put ball (211) and seat (231) into shuttle valve cover (202).

☞ Pay attention to the direction of seat (231).

8) Attach O ring (261) to plug (251) and tighten the plug against shuttle valve cover (202) to a specified torque.

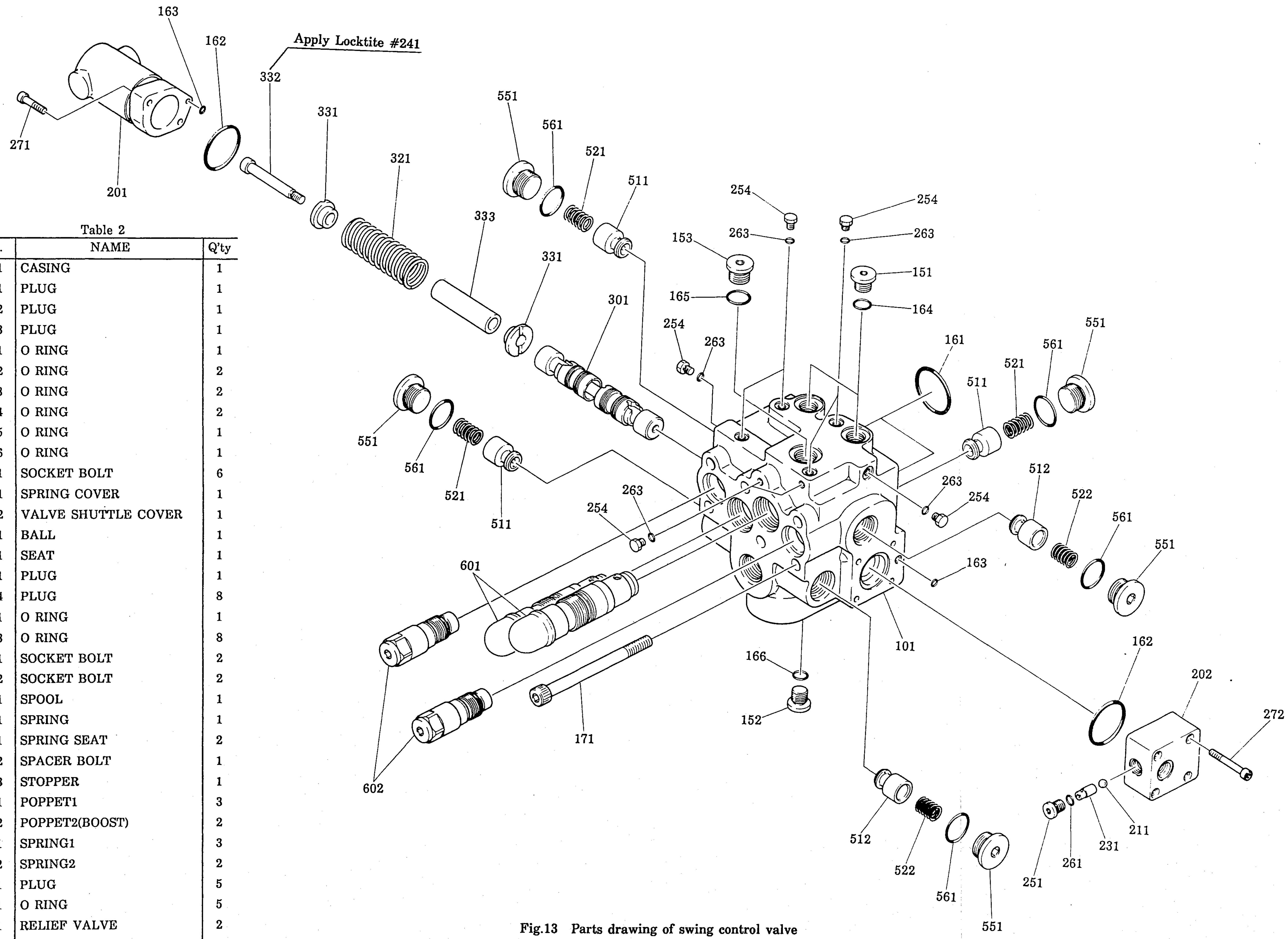
9) Fix shuttle valve cover (202) to casing (101) using socket bolt (272) and tighten the socket bolt to a specified torque.

☞ Align the pilot path in shuttle valve cover (202) to the hole of casing (101) before fixing them together.

(10) Attach O ring (161) to casing (101).

(11) Internal rust prevention
Fill volatile rust preventive medium inside and put polyethylene plugs in order to prevent rusting due to moisture condensation.

This completes assembly.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251
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231
211

Table 2

No.	NAME	Q'ty
101	CASING	1
151	PLUG	1
152	PLUG	1
153	PLUG	1
161	O RING	1
162	O RING	2
163	O RING	2
164	O RING	2
165	O RING	1
166	O RING	1
171	SOCKET BOLT	6
201	SPRING COVER	1
202	VALVE SHUTTLE COVER	1
211	BALL	1
231	SEAT	1
251	PLUG	1
254	PLUG	8
261	O RING	1
263	O RING	8
271	SOCKET BOLT	2
272	SOCKET BOLT	2
301	SPOOL	1
321	SPRING	1
331	SPRING SEAT	2
332	SPACER BOLT	1
333	STOPPER	1
511	POPPET1	3
512	POPPET2(BOOST)	2
521	SPRING1	3
522	SPRING2	2
551	PLUG	5
561	O RING	5
601	RELIEF VALVE	2
602	SWING-SHOCKLESS VALVE	2

Fig.13 Parts drawing of swing control valve

4. MAINTENANCE STANDARDS

4.1 INSPECTING PARTS

Table 6

Part Name	Inspection Item	Acceptance Standard and Remedy
Casing	Presence of scratch, rusting and corrosion	Replace parts that show damage on the following areas: o Sliding surface between casing hole and spool, particularly on the land area o Seal pocket into which spool enters o Sealing surface of ports in contact with O rings o Sealing surface of relief valves o Other damage considered to mar normal functions
Spool	1) Presence of scratch, galling, rust and corrosion	1) Where spool has a scratch large enough to be caught by nail, replace it. (especially over the area in contact with seals)
	2) Sealing surface of O rings at both ends	2) Replace spool that has fault on its sliding surface.
	3) Put spool into casing hole and stroke it while rotating it.	3) Correct or replace spool that has a fault possible to damage O ring or that obstructs its smooth movement.
Poppet	1) Damage to poppet and spring	1) Correct or replace poppet showing incomplete sealing effect.
	2) Put poppet into casing and let it work.	2) Poppet is normal if it functions smoothly without being arrested.
Spring and associated parts	1) That springs, spring seats and caps are rusted, corroded, deformed or broken.	1) Replace parts that show excessive damage.
	2) Small air bleeding hole in cap is clogged.	2) Replace parts that show excessive damage.
Seal of spool and the area around it	1) External oil leakage	1) Correct or replace
	2) Rusting, corrosion and deformation of seal plate	2) Correct or replace
Relief valve	1) External rusting and damage	1) Replace.
	2) Contact surface of valve seat	2) Replace one that is damaged.
	3) Contact surface of poppet	3) Replace one showing damage.
	4) Abnormality of springs	4) Replace.
	5) O rings, backup rings and seals	5) Replace all in principle.

4.2 TIGHTENING TORQUE

KSC15R

Table 7

Tools	No.	Part Name	Screw Size	Tightening Torque kgf·cm (ft·lbs)
Hex key wrench	271	Socket bolt	M6	120±18〔8.7±1.3〕
	272	Socket bolt		
	251	Plug	M12	100~125〔7.2~9.0〕
	151	Plug	PF3/8	750±50〔54.1±3.6〕
	332	Spacer bolt	M8	160~180〔11.5~13.0〕
	171	Socket bolt	M12	700±70〔50.6±5.1〕
	153	Plug	PF1/2	1100±100〔79.4±7.2〕
	551	Plug	M24	1300±100〔93.9±7.2〕
Wrench	473	Relief valve locknut	M12	280±20〔20.2±1.4〕
	253,152	Plug	PF1/4	350~400〔25.3~28.9〕
	602	Anti-turnover valve	M22	700±800〔50.6±57.8〕
	601	Relief valve	M33	1500±150〔108.3±10.8〕
Torque wrench	100~2,000kgf·cm (7.22~144 ft·lbs)			

4.3 ADJUSTING RELIEF VALVE

1) Connect a calibrated pressure gauge to each of the LH/RH pressure measuring ports (PF3/8) on the swing control valve.
2) Run the pump at the rated revolution.

☞ After sufficient idling, relieve oil by operating the bucket or the arm till the oil temperature gets to 50°C.

3) Press the bucket against sand and soil.
4) Operate the swing control lever slowly to its full stroke and read the pressure gauge reading.
5) Adjust setscrew (471) till required pressure is available.
6) Turning setscrew (471) clockwise increases pressure and turning it counterclockwise decreases pressure. Shown below are references for pressure changes.

Table 8

Setscrew revolution meter	Pressure change kgf/cm^2 (psi)
1 turn	About 134〔1906〕
1/4 turn	About 33〔469〕

7) When the specified pressure has been attained, fix setscrew (471) and tighten locknut (473) to the specified torque.
8) Make sure once again that the pressure is at the specified level.
9) Lastly, attach cap (851) locknut (473).

5. TROUBLESHOOTING

(1) Hydraulic motor does not start.

Table 9

Trouble	Cause	Remedy
Pressure does not rise.	1) Relief valve is out of order	
	a. Relief valve plunger is stuck.	a. Repair or replace relief valve.
	b. Relief valve spring is broken.	b. Replace spring.
	c. Relief valve is undertightened.	c. Tighten to the specified torque.
	d. Relief valve is set incorrectly.	d. Adjust to the specified pressure.
	e. Plunger restrictor is clogged.	e. Clean or replace.
	2) Relief malfunctions	
	a. Spool is stuck with casing.	a. Remove dirt in hydraulic oil. Correct or replace faulty parts.
	b. Clearance between spool and casing is too large.	b. Replace spool or replace assembly.
	c. Casing is distorted by tightening of mounting capscrews, piping flanges and others.	c. Tighten to the specified torque.
	d. Surface fault is present on seat surface.	d. Repair with an oilstone or replace.
	3) Malfunctioning of pilot-operated shuttle valve	
	a. Dirt included between the ball and the seat	a. Disassemble and clean.
	b. Scoring produced on the seat surface	b. Correct with an oilstone or replace
	4) Anti-cavitation check valve is out of order.	
	a. Plunger is stuck or seat surface has fault.	a. Repair or replace faulty parts.
Pressure rises.	1) Holding check valve is out of order.	
	a. Plunger is stuck.	a. Repair or replace faulty parts.

(2) Brake operation is impossible.

Table 10

Trouble	Cause	Remedy
Reverse brake works.	1) Spool malfunctions.	
	a. See 5.(1).2).	a. See 5.(1).2).
	b. Spring is damaged or fatigued.	b. Replace spring.
Reverse brake does not work.	1) Relief valve is out of order.	
	a. See 5.(1).1).	a. See 5.(1).1).
	2) Anti-cavitation check valve is out of order.	
	b. See 5.(1).4).	b. See 5.(1).4).

(3) Abnormal noise comes out.

Table 11

Trouble	Cause	Remedy
Abnormal noise comes out at startup also.	1) Relief valve develops hunting. a. Hole in plunger restrictor is too large.	a. Replace.
Abnormal noise comes out only when brake is applied.	1) Cavitation of hydraulic moter a. Boost check valve and anti-cavitation check valve plungers are stuck. b. Boost check valve spring is broken.	a. Repair or replace. b. Replace spring.

(4) Swing slips on a slope

Table 12

Trouble	Cause	Remedy
Holding performance against external force is not satisfactory.	1) Relief valve is out of order. a. See 5.(1).1). 2) Spool malfunctions. a. See 5.(1).2). 3) Anti-cavitation check valve is out of order. a. See 5.(1).4).	a. See 5.(1).1) a. See 5.(1).2) a. See 5.(1).4)

Book code No. S5 13070 2E

KOBELCO

SHOP MANUAL

CONTROL VALVE

13

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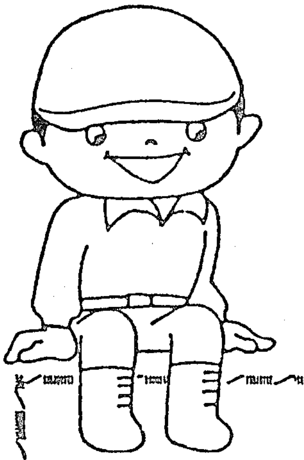
KOBE STEEL, LTD.



PREFACE

This is a composite valve containing a direction control valve that controls the actuator motion by changing the valve circuit, a relief valve that holds the circuit pressure within a safe pressure range, various selector valves, conflux valves and sequence valves.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE－11001～				

Revision	Date of Issue	Remarks
First edition	June, 1990	S5130702E K

1. SPECIFICATION

1.1 GENERAL VIEW

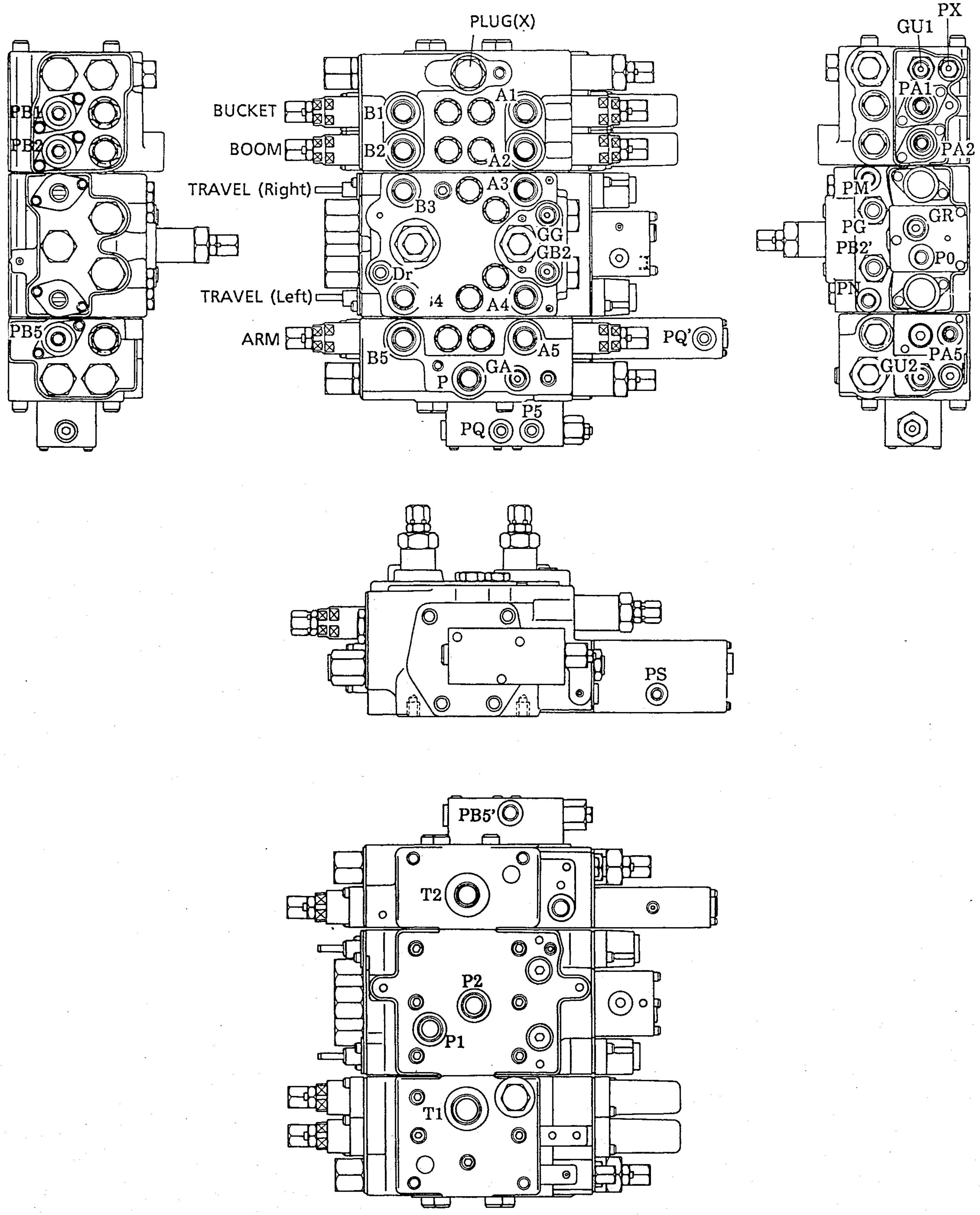


Fig. 1

Table 1

Port Mark	Size	Item	Port Mark	Size	Item
		(Main port)			(Measuring port)
P1	PF1/2	Pump P1 port	GA	PF1/4	Pressure gauge port
P2	PF1/2	Pump P2 port	GU1	PF1/4	Pressure gauge port
P	PF1/2	Swing pump port	GU2	PF1/4	Pressure gauge port
T1	PF1/2	Tank port	GB2	PF1/4	Pressure gauge port
T2	PF1/2	Tank port	GG	PF1/4	Pressure gauge port
A1	PF1/2	Bucket release port	PM	PF1/4	Travel neutral detecting signal port
B1	PF1/2	Bucket digging port			
A2	PF1/2	Boom lowering port	PN	PF1/4	Travel neutral detecting signal port
B2	PF1/2	Boom hoisting port			
A3	PF1/2	Travel (RH) backward port			
B3	PF1/2	Travel (RH) forward port			
A4	PF1/2	Travel (LH) backward port			
B4	PF1/2	Travel (LH) forward port			
A5	PF1/2	Arm release port			
B5	PF1/2	Arm digging port			
PX	PF1/4	Service port			
		(Pilot port)			
PA1	PF1/4	Bucket release pilot port			
PB1	PF1/4	Bucket digging pilot port			
PA2	PF1/4	Boom lowering pilot port			
PB2	PF1/4	Boom hoisting pilot port			
PA5	PF1/4	Arm release pilot port			
PB5	PF1/4	Arm digging pilot port			
PB5'	PF1/4	Sequence valve pilot port			
P0	PF1/4	Pilot port			
PQ	PF1/4	Sequence valve pilot port			
PS	PF1/4	Swing pilot port			
PG	PF1/4	Arm confluent valve pilot port			
PB2'	PF1/4	Boom confluent valve pilot port			
P5	PF1/4	Sequence valve pilot port			
Dr	PF1/4	Pilot drain port			

1.2 SPECIFICATION

Table 2

Item	Specification
Model	BCV－8A
Max. Pressure	260 kgf/cm2 (3700 psi)
Set pressure of main relief valve	210 $^{+5}_{0}$ kgf/cm²(2990 $^{+71}_{0}$ psi)at 65ℓ/min (17.2gal/min)
Set pressure at travel relief valve	260 $^{+5}_{0}$ kgf/cm²(3700 $^{+71}_{0}$ psi)at 80ℓ/min (21.1gal/min)
Set pressure of port relief valve	240 $^{+5}_{0}$ kgf/cm²(3410 $^{+71}_{0}$ psi)at 70ℓ/min (18.5gal/min)

1. SPECIFICATION

1.1 GENERAL VIEW : Pilot travel spec. (Model BCV-8AP)

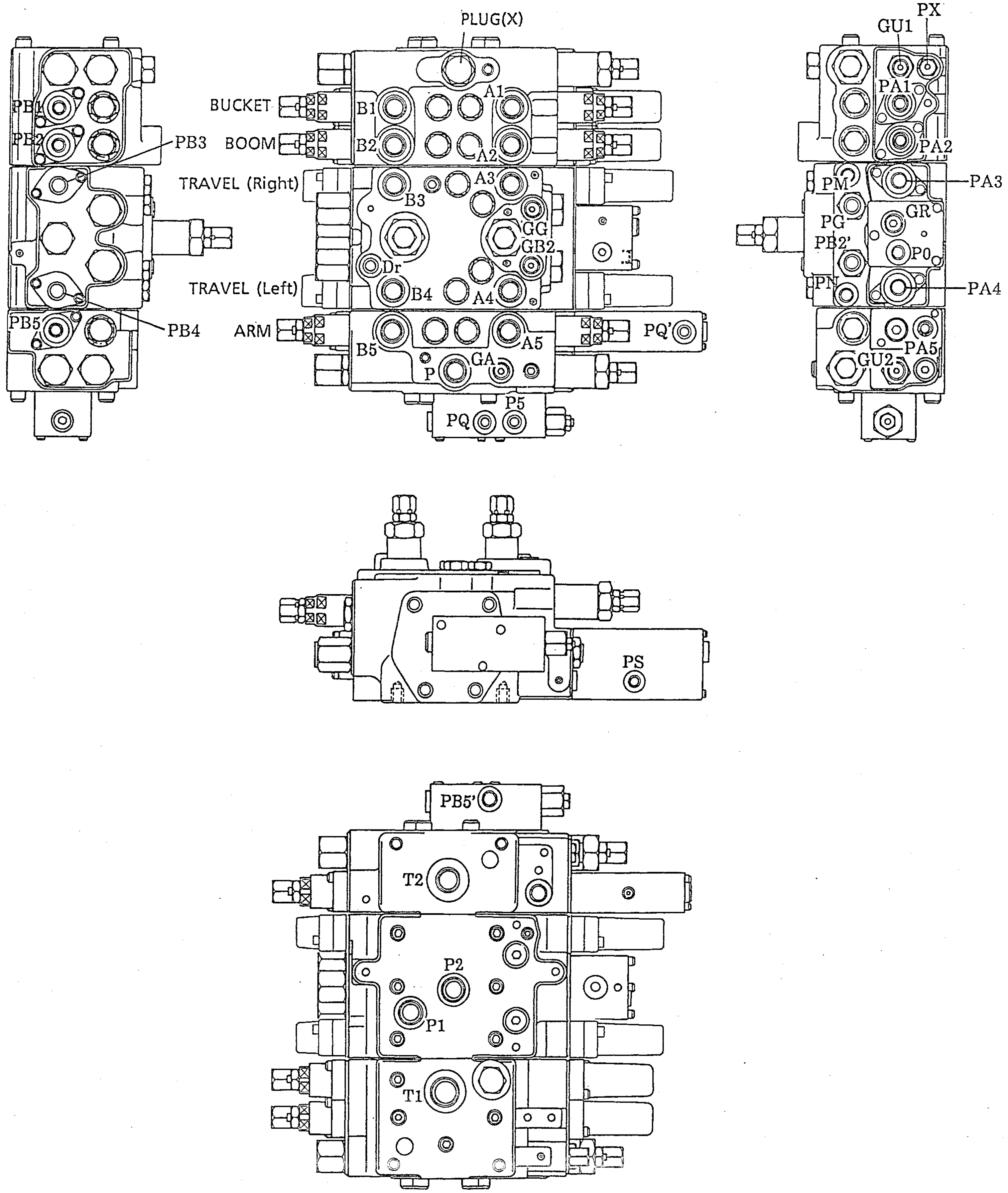


Fig. 1B

Table 1B

Port Mark	Size	Item	Port Mark	Size	Item
		(Main port)			(Measuring port)
P1	PF1/2	Pump P1 port	GA	PF1/4	Pressure gauge port
P2	PF1/2	Pump P2 port	GU1	PF1/4	Pressure gauge port
P	PF1/2	Swing pump port	GU2	PF1/4	Pressure gauge port
T1	PF1/2	Tank port	GB2	PF1/4	Pressure gauge port
T2	PF1/2	Tank port	GG	PF1/4	Pressure gauge port
A1	PF1/2	Bucket release port	PA3	PF1/4	Travel L.H advance
B1	PF1/2	Bucket digging port	PB3	PF1/4	Travel L.H retreat
A2	PF1/2	Boom lowering port	PA4	PF1/4	Travel R.H advance
B2	PF1/2	Boom hoisting port	PB4	PF1/4	Travel R.H retreat
A3	PF1/2	Travel (RH) backward port			
B3	PF1/2	Travel (RH) forward port			
A4	PF1/2	Travel (LH) backward port			
B4	PF1/2	Travel (LH) forward port			
A5	PF1/2	Arm release port			
B5	PF1/2	Arm digging port			
PX	PF1/4	Service port			
		(Pilot port)			
PA1	PF1/4	Bucket release pilot port			
PB1	PF1/4	Bucket digging pilot port			
PA2	PF1/4	Boom lowering pilot port			
PB2	PF1/4	Boom hoisting pilot port			
PA5	PF1/4	Arm release pilot port			
PB5	PF1/4	Arm digging pilot port			
PB5'	PF1/4	Sequence valve pilot port			
P0	PF1/4	Pilot port			
PQ	PF1/4	Sequence valve pilot port			
PS	PF1/4	Swing pilot port			
PG	PF1/4	Arm confluent valve pilot port			
PB2'	PF1/4	Boom confluent valve pilot port			
P5	PF1/4	Sequence valve pilot port			
Dr	PF1/4	Pilot drain port			

1.2 SPECIFICATION

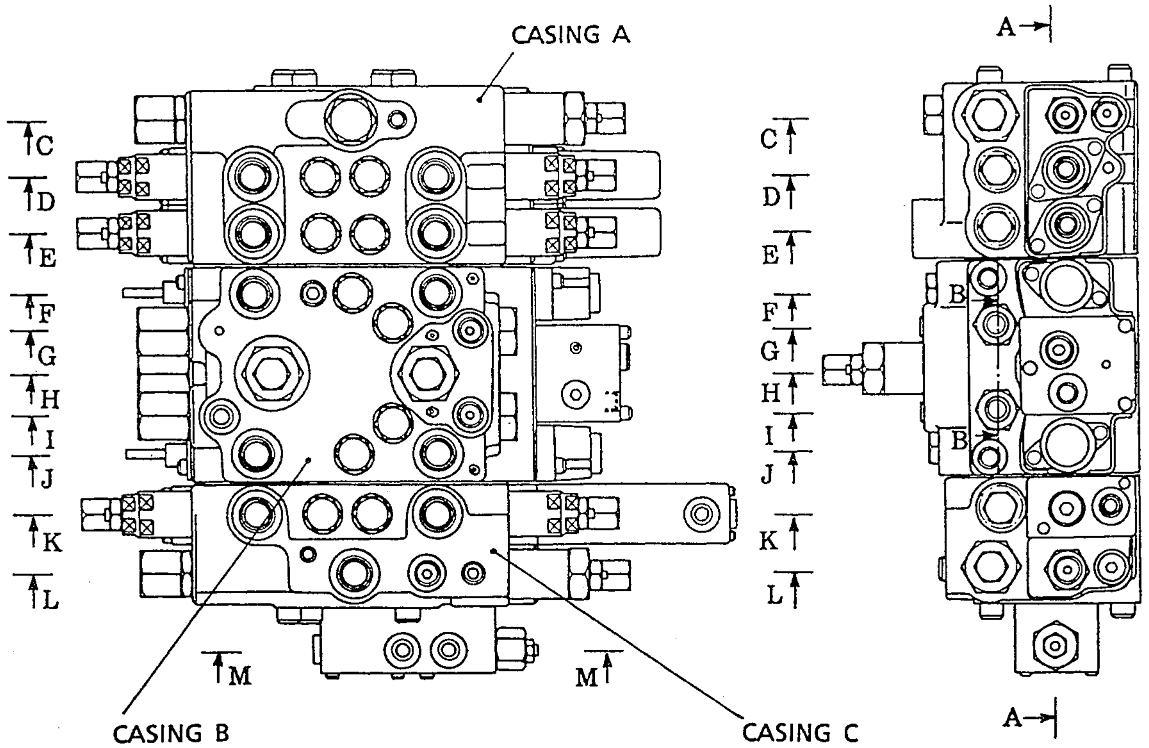
Table 2B

Item	Specification
Model	BCV−8AP
Max. Pressure	260 kgf/cm2 (3700 psi)
Set pressure of main relief valve	210^{+5}_{0} kgf/cm²(2990 $^{+71}_{0}$psi)at 65ℓ/min (17.2gal/min)
Set pressure at travel relief valve	260^{+5}_{0} kgf/cm²(3700 $^{+71}_{0}$psi)at 80ℓ/min (21.1gal/min)
Set pressure of port relief valve	240^{+5}_{0} kgf/cm²(3410 $^{+71}_{0}$psi)at 70ℓ/min (18.5gal/min)

2, CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION

(1) Control Valve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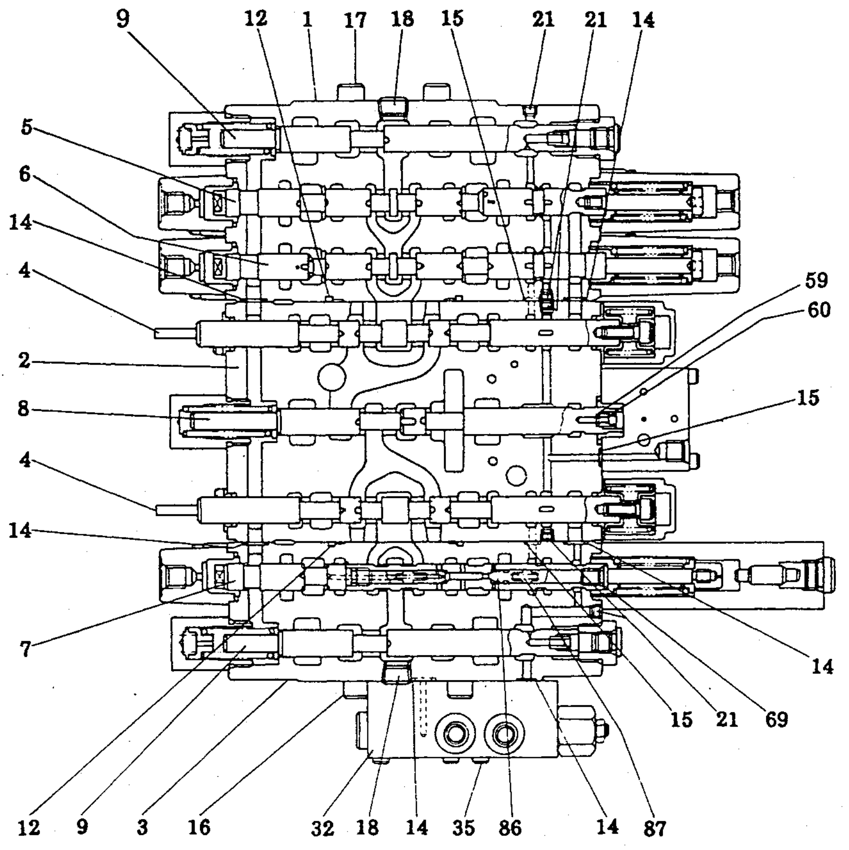
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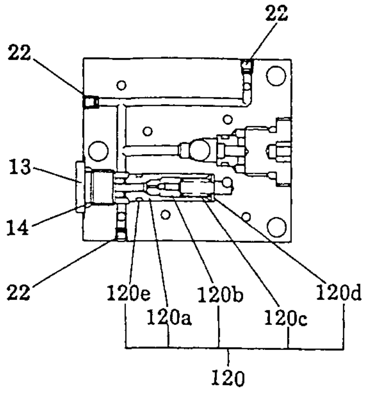
SECTION A – A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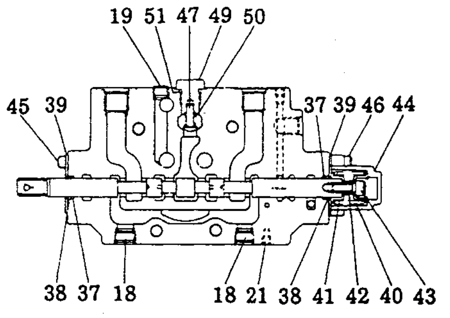
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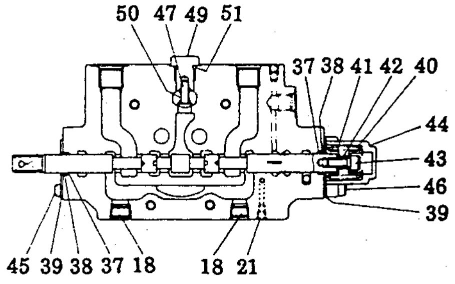
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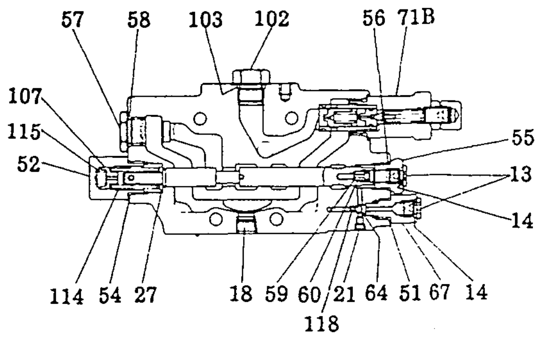
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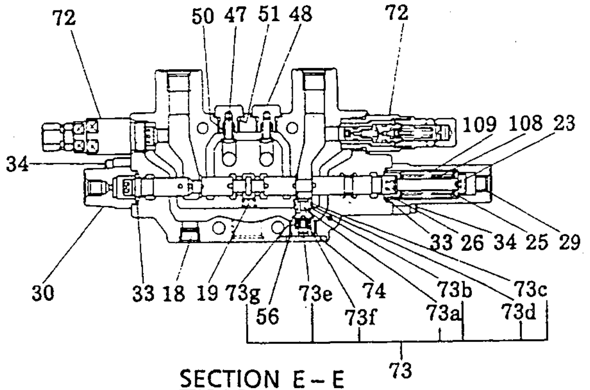
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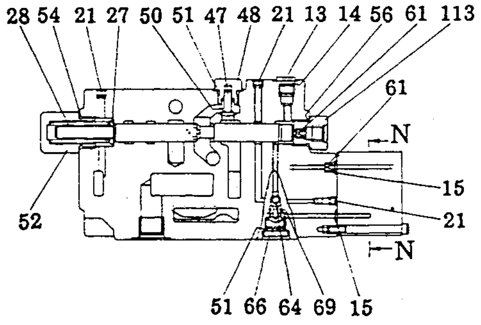
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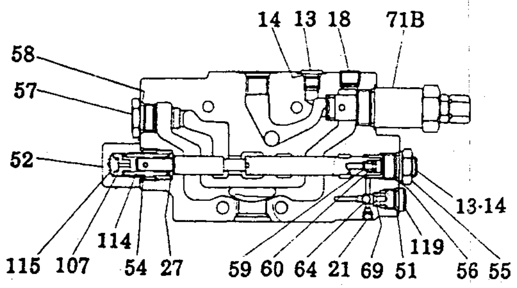
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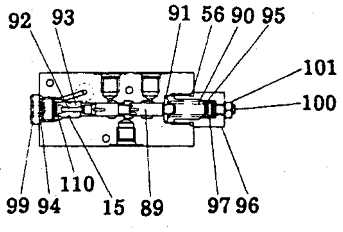
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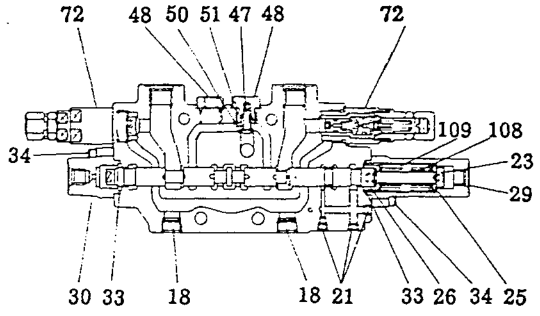
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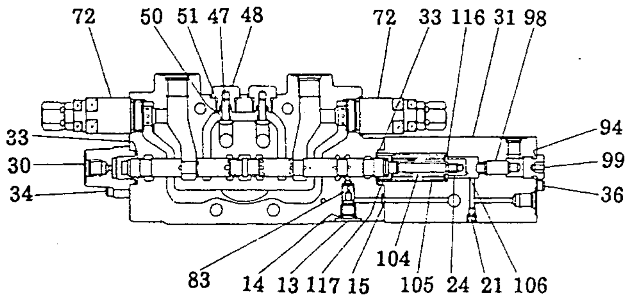
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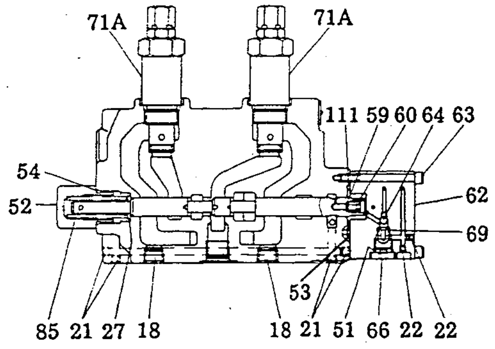
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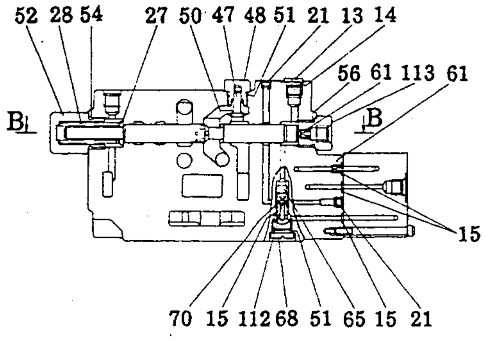
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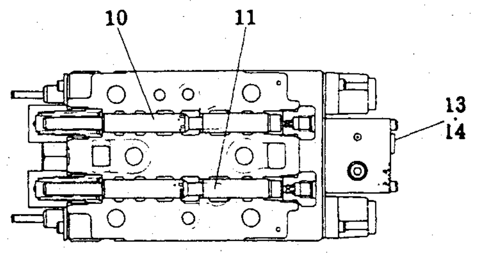


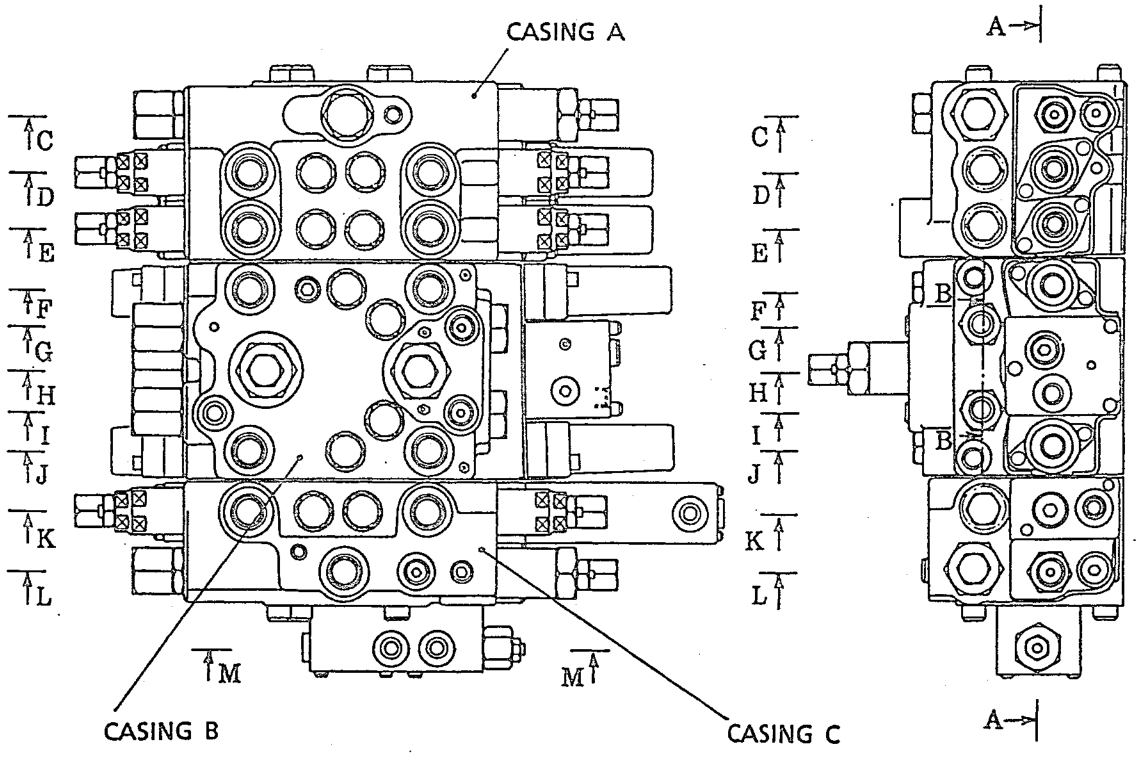
SECTION B – B

Fig. 2A

2, CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION

(1) Control Valve : pilot travel spec. (Model ; BCV-8AP)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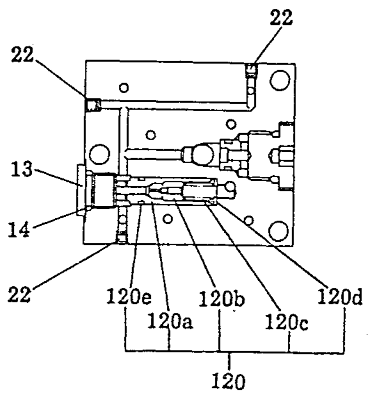
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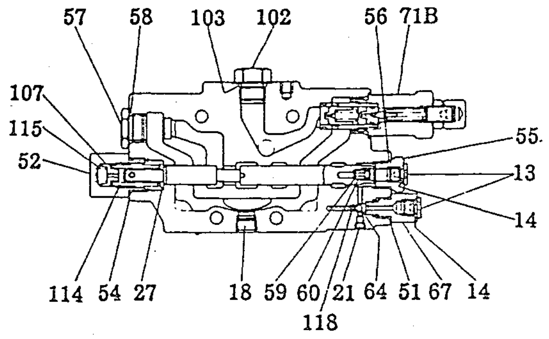
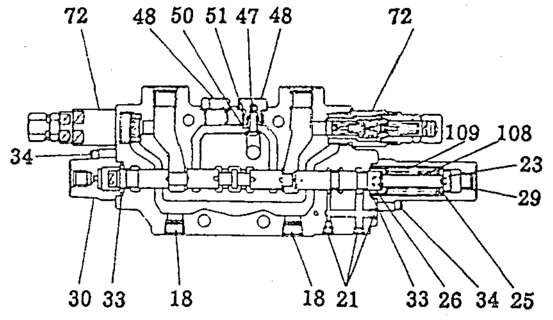
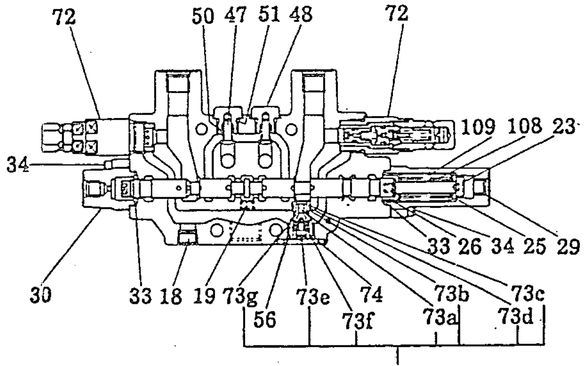

57 58 103 102 56 71B
107
115
52
55
13
14
114 54 27 18 59 60 21 64 51 67 14
118

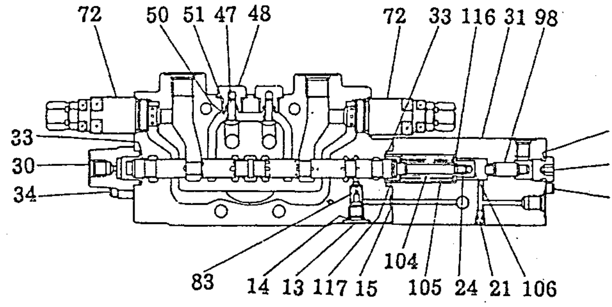
SECTION C – C


72 48 50 51 47 48 72
34
109 108
23
29
30 33 18 18 21 33 26 34 25

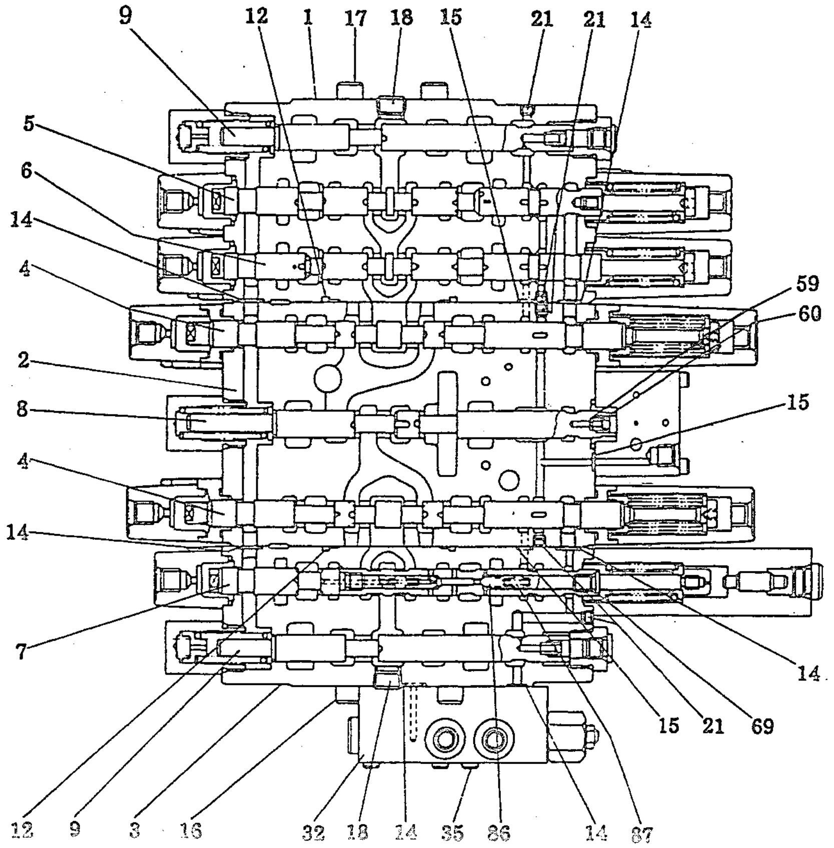
SECTION D – D


72 50 47 51 48 72
109 108 23
34
30
33 18 19 73g 56 73e 73f 74 73b 73a 73c 73d
33 26 34 25 29
73

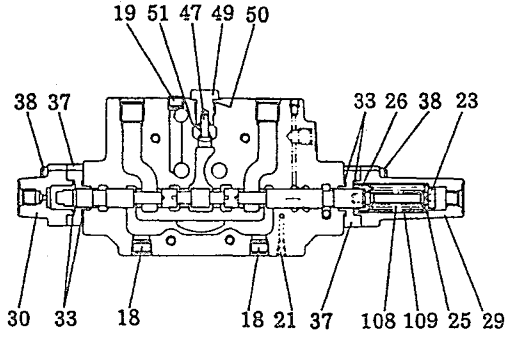
SECTION E – E


72 50 51 47 48 72 33 116 31 98
33
30
34
94
99
36
83 14 13 117 15 104 105 24 21 106

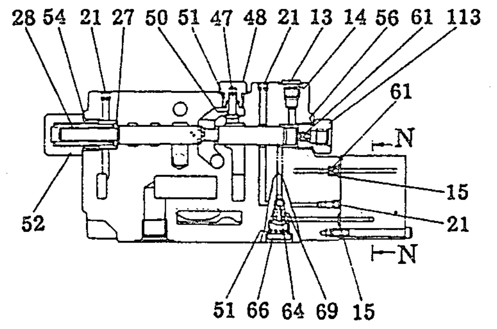
SECTION K – K


9 12 1 17 18 15 21 21 14
5
6
14
4
59
60
2
8
15
4
14
7
14
12 9 3 16 32 18 14 35 86 14 87
15 21 69

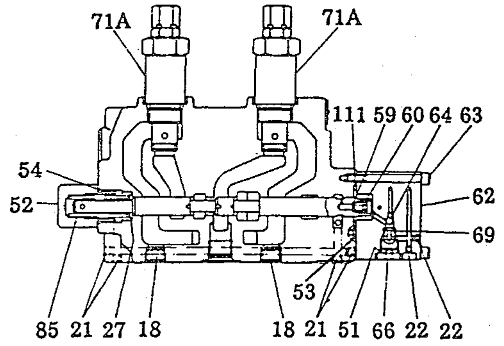
SECTION A – A


19 51 47 49 50
38 37
33 26 38 23
30 33 18 18 21 37 108 109 25 29

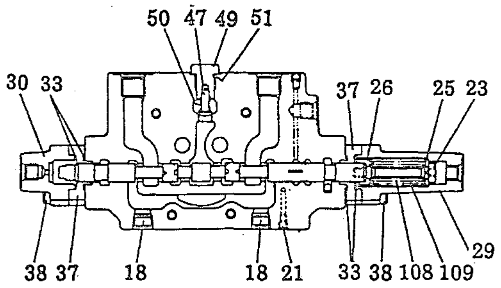
SECTION F – F


28 54 21 27 50 51 47 48 21 13 14 56 61 113
61
N
15
21
N
52
51 66 64 69 15

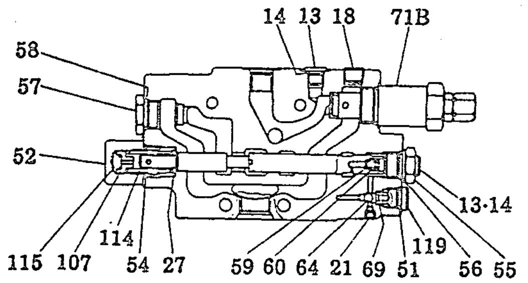
SECTION G – G


71A 71A
111 59 60 64 63
54
52
62
69
53
85 21 27 18 18 21 51 66 22 22

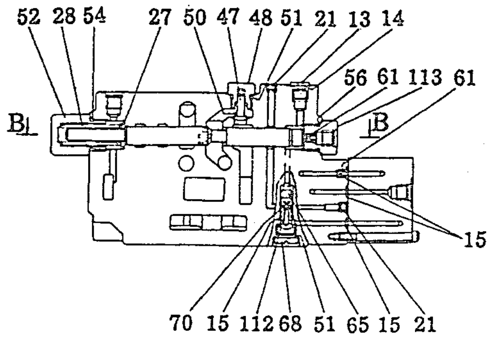
SECTION H – H


50 47 49 51
30 33
37 26 25 23
29
38 37 18 18 21 33 38 108 109

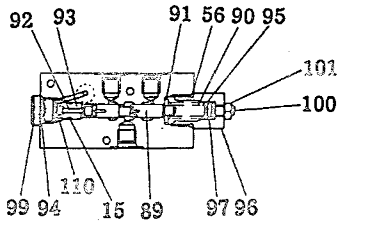
SECTION J – J


14 13 18 71B
58
57
52
13·14
119
115 107 114 54 27 59 60 64 21 69 51 56 55

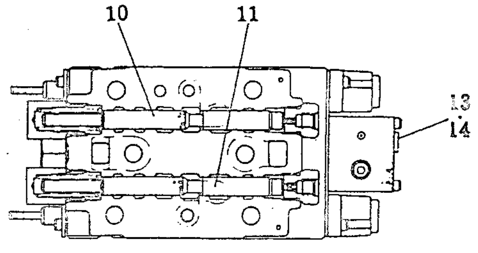
SECTION L – L


52 28 54 27 50 47 48 51 21 13 14
56 61 113 61
B
B
15
70 15 112 68 51 65 15 21

SECTION I – I


92 93 91 56 90 95
101
100
99 94 110 15 89 97 96

SECTION M – M



SECTION B – B

Fig. 2B

Table 3

No.	NAME	Q' ty	No.	NAME	Q' ty	No.	NAME	Q' ty
1	CASING (A)	1	41	SPRING SEAT	4	91	SEQUENCE VALVE	1
2	CASING (B)	1	42	SPACER	2		SEAT	
3	CASING (C)	1	43	SOCKET BOLT	2	92	PILOT PISTON	1
4	SPOOL (For travel)	2	44	COVER	2	93	PISTON GUIDE	1
5	SPOOL (For bucket)	1	45	SOCKET BOLT	4	94	O RING	3
6	SPOOL (For boom)	1	46	SOCKET BOLT	4	95	PISTON	1
7	SPOOL ASS'Y		47	POPPET	9	96	PISTON CASE	1
	(For boom)	1	48	POPPET SEAT	8	97	O RING	1
7-a	ARM SPOOL (A)	1	49	POPPET SEAT	2	98	PISTON	1
7-b	ARM SPOOL (B)	1	50	SPRING	9	99	PLUG	2
7-c	VALVE	1	51	O RING	15	100	ADJUSTER SCREW	1
7-d	SPRING	1	52	CAP	5	101	HEXAGON NUT	1
7-e	O RING	1	53	O RING	1	102	PLUG	1
8	SPOOL (For straight travel)	1	54	O RING	5	103	O RING	1
9	SPOOL (For cat valve)	2	55	BUSHING	2	104	SPRING	1
10	SPOOL (For arm		56	O RING	6	105	SPRING	1
	conflux valve)	1	57	PLUG	2	106	CAP	1
11	SPOOL (For boom		58	O RING	2	107	STOPPER	2
	conflux valve)	1	59	FILTER	3	108	SPRING	2
12	O RING	2	60	RETAINER	3	109	SPRING	2
13	PLUG	9	61	ORIFICE	4	110	SPRING PIN	1
14	O RING	13	62	TRAVEL STRAIGHT		111	O RING	1
15	O RING	13		VALVE CASING	1	112	BALL	1
16	SOCKET BOLT	4	63	SOCKET BOLT	3	113	BUSHING	2
17	SOCKET BOLT	4	64	BALL	4	114	SPRING	2
18	SOCKET BOLT	13	65	SHUTTLE VALVE	1	115	SPRING	2
19	SOCKET BOLT	3	66	SHUTTLE VALVE PLUG	2	116	SPRING SEAT	1
21	SCREW PLUG	35	67	SHUTTLE VALVE PLUG	1	117	SPRING SEAT	1
22	SCREW PLUG	8	68	SHUTTLE VALVE PLUG	1	118	SPRING	1
23	SPOOL END	2	69	O RING	5	119	SHUTTLE VALVE PLUG	1
24	SPOOL END	1	70	SPRING	1	120	POPPET ASS'Y	1set
25	SPRING SEAT	2	71-A	MAIN RELIEF VALVE				
26	SPRING SEAT	2		ASS'Y (For travel)	2set			
27	SPRING SEAT	5	71-B	MAIN RELIEF VALVE				
28	SPRING	2		ASS'Y(For attachment)	2set			
29	COVER	2	72	PORT RELIEF				
30	COVER	3		VALVE ASS'Y	6set			
31	SPRING CASE	1	73	ANTI-CAVITATION				
32	SEQUENCE VALVE	1		VALVE ASS'Y	1set			
33	O RING	6	74	CAP	1			
34	SOCKET BOLT	6	83	LOGIC VALVE	1			
35	SOCKET BOLT	3	85	SPRING	1			
36	SOCKET BOLT	2	86	POPPET	1			
37	O RING	4	87	SPRING	1			
38	DUST WIPER	4	89	SEQUENCE VALVE				
39	OIL SEAL RETAINER	4	90	SPOOL	1			
40	SPRING	2		SPRING	1			

(2) Main Relief Valve

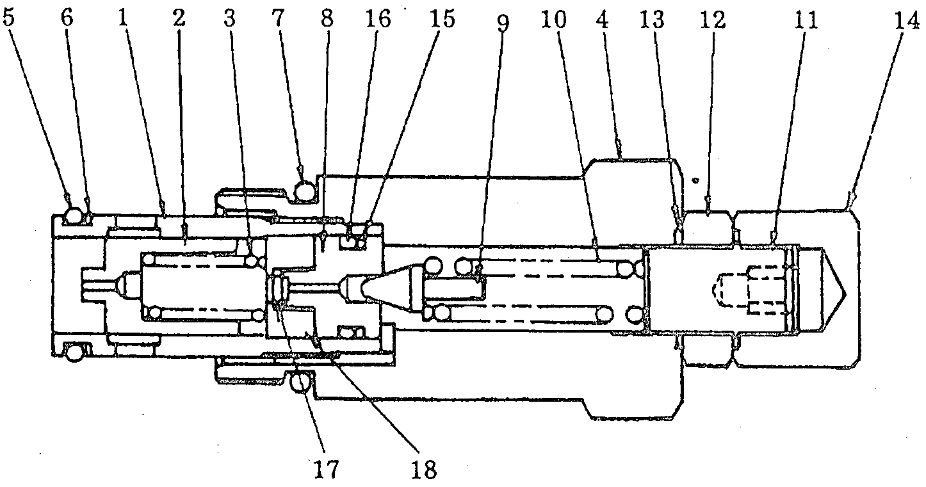

5
6
1
2
3
7
8
16
15
9
10
4
13
12
11
14
17
18

Fig. 3

Table 3

No.	NAME	Q' ty	No.	NAME	Q' ty	No.	NAME	Q' ty
1	SOCKET	1	7	O RING	1	13	O RING	1
2	PLUNGER	1	8	SEAT	1	14	LOCK NUT	1
3	SPRING	1	9	POPPET	1	15	BACK-UP RING	1
4	BODY	1	10	SPRING	1	16	O RING	1
5	O RING	1	11	ADJUSTING SCREW	1	17	FILTER	1
6	BACK-UP RING	1	12	NUT	1	18	FILTER SEAT	1

(3) Port Relief Valve

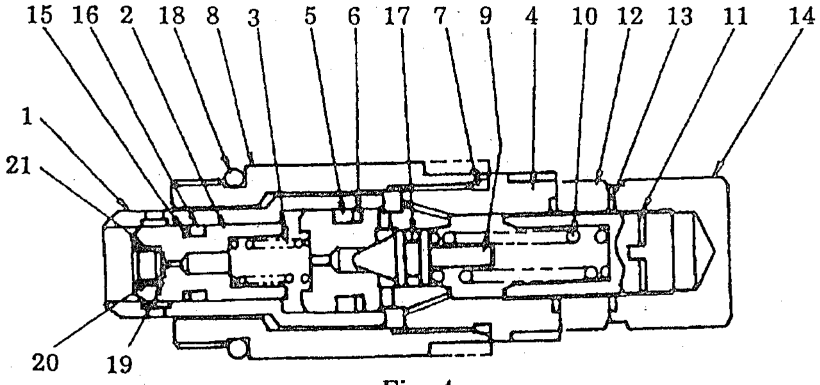
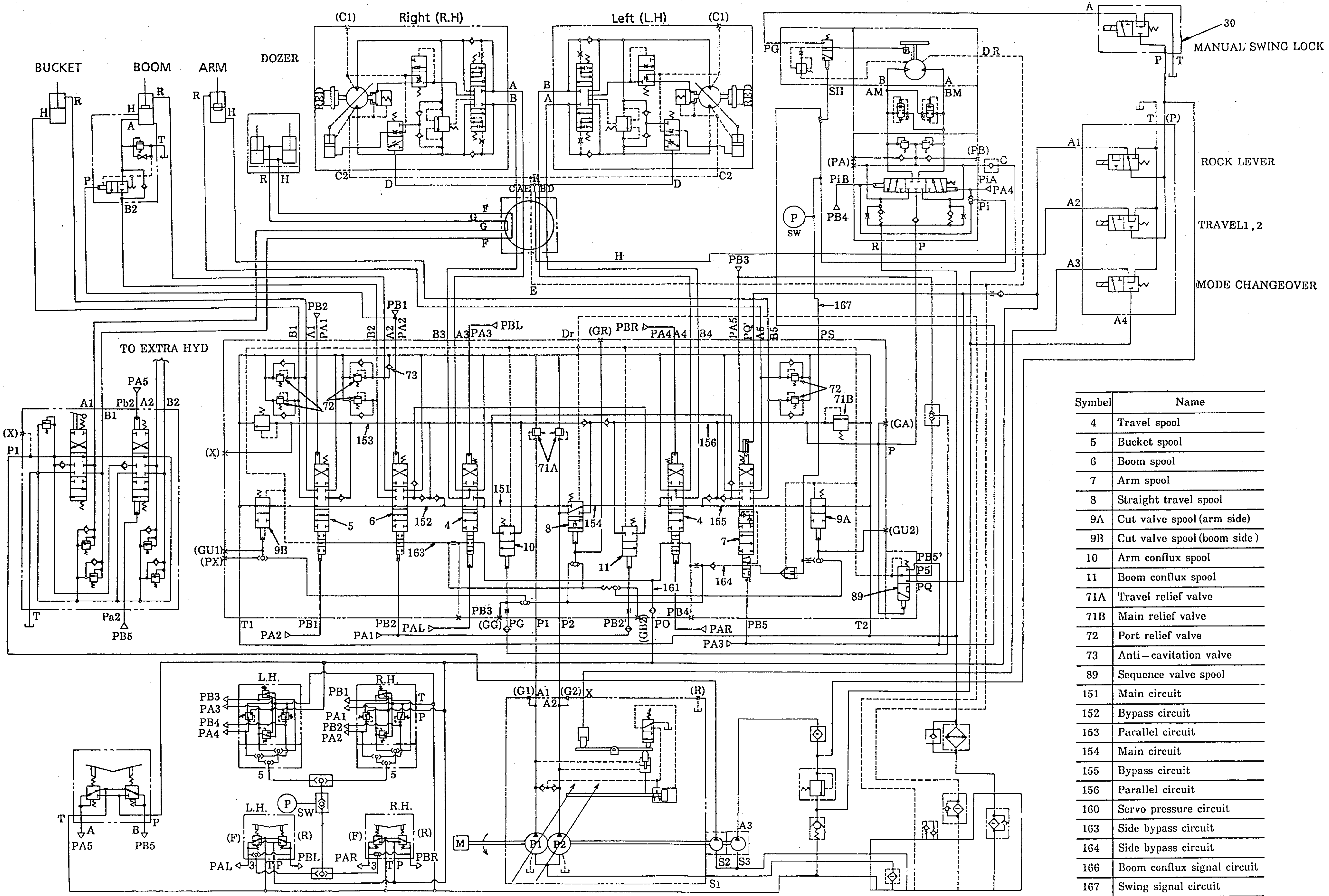

15
16
2
18
8
3
5
6
17
7
9
4
10
12
13
11
14
1
21
20
19

Fig. 4

Table 4

No.	NAME	Q' ty	No.	NAME	Q' ty	No.	NAME	Q' ty
1	SOCKET	1	8	BODY	1	15	BACK-UP RING	1
2	PLUNGER	1	9	POPPET	1	16	O RING	1
3	SPRING	1	10	SPRING	1	17	SEAL	1
4	BODY	1	11	ADJUSTING SCREW	1	18	O RING	1
5	O RING	1	12	NUT	1	19	FILTER	1
6	BACK-UP RING	1	13	O RING	1	20	SPACER	1
7	O RING	1	14	LOCK NUT	1	21	SNAP RING	1

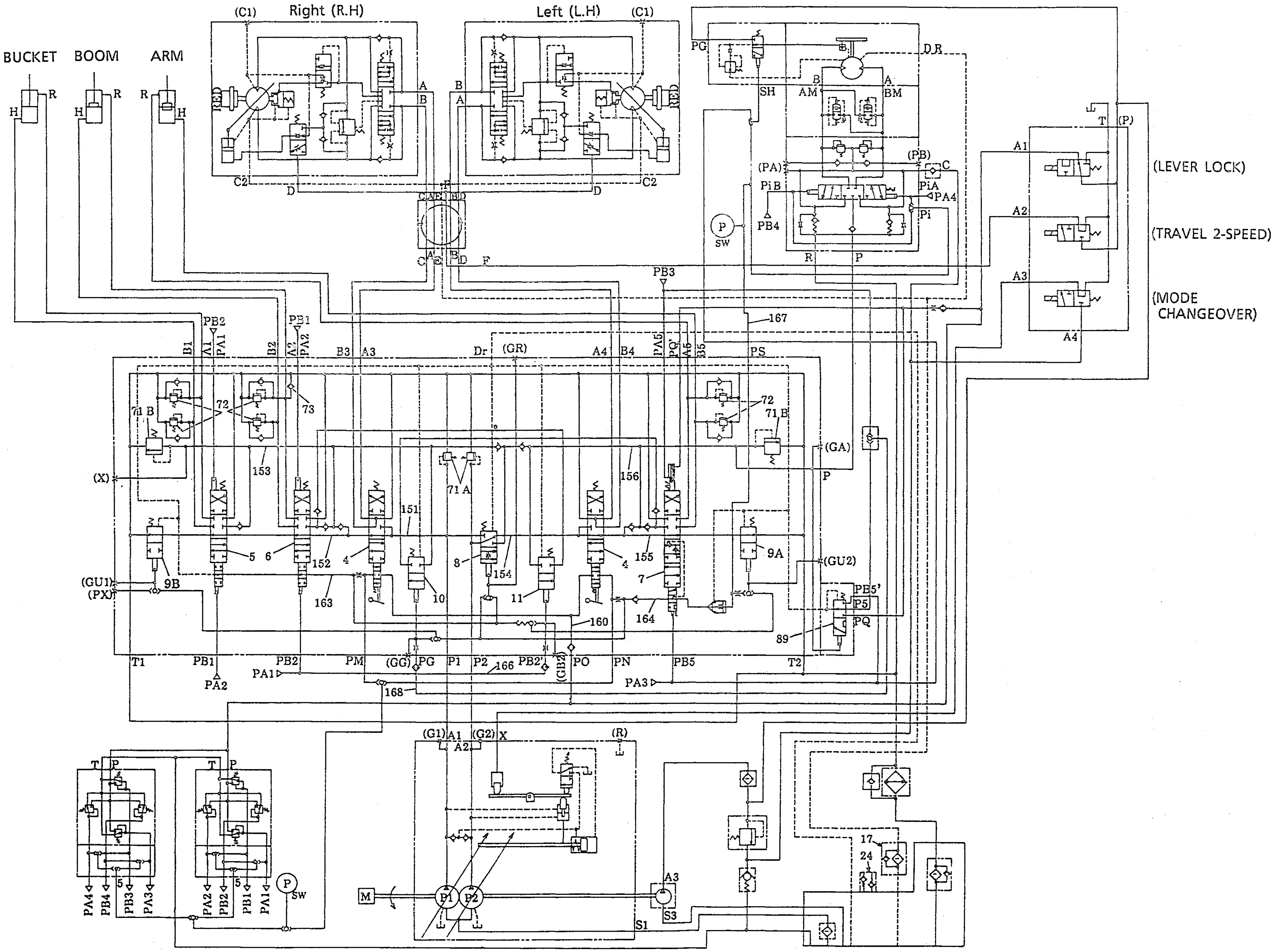
Pilot travel & wrist control spec.


BUCKET
BOOM
ARM
DOZER
Right (R.H)
Left (L.H)
(C1)
C2
MANUAL SWING LOCK
30
ROCK LEVER
TRAVEL1, 2
MODE CHANGEOVER
TO EXTRA HYD
PG
SH
DR
AM
BM
(PA)
(PB)
PiA
PiB
PA4
PB4
SW
PB3
A1
A2
A3
A4
PB1
PB2
PBL
PBR
PA1
PA2
PA3
PA5
B1
B2
B3
B4
B5
PS
Dr
(GR)
72
73
153
71A
71B
156
151
152
154
155
163
161
164
167
9A
9B
10
11
89
(GA)
(GU1)
(GU2)
(PX)
(X)
T1
T2
PAL
PAR
PB5
P1
P2
PO
(GG)
(GB2)
L.H.
R.H.
(G1)
(G2)
(R)
M
S1
S2
S3
(F)
PA5
PB5

Symbel	Name
4	Travel spool
5	Bucket spool
6	Boom spool
7	Arm spool
8	Straight travel spool
9A	Cut valve spool (arm side)
9B	Cut valve spool (boom side)
10	Arm conflux spool
11	Boom conflux spool
71A	Travel relief valve
71B	Main relief valve
72	Port relief valve
73	Anti-cavitation valve
89	Sequence valve spool
151	Main circuit
152	Bypass circuit
153	Parallel circuit
154	Main circuit
155	Bypass circuit
156	Parallel circuit
160	Servo pressure circuit
163	Side bypass circuit
164	Side bypass circuit
166	Boom conflux signal circuit
167	Swing signal circuit
168	Arm conflux signal circuit

Fig. 5B Hydraulic circuit diagram

2.3 HYDRAULIC CIRCUIT DIAGRAM AND PART DESIGNATION


BUCKET
BOOM
ARM
H
R
(C1)
Right (R.H)
Left (L.H)
(C1)
RED
A
B
C2
D
PG
DR
SH
AM
BM
(PA)
(PB)
C
PiB
PiA
PA4
Pi
PB4
P
SW
R
P
A1
A2
A3
A4
T
(P)
(LEVER LOCK)
(TRAVEL 2-SPEED)
(MODE CHANGEOVER)
C
E
D
F
PB3
167
PB2
PB1
B1
A1
PA1
B2
A2
PA2
B3
A3
Dr
(GR)
A4
B4
PA5
PQ'
A5
B5
PS
71 B
72
73
153
(X)
71 A
151
156
72
71 B
(GA)
P
5
6
152
4
8
154
10
11
4
155
7
9A
(GU2)
(GU1)
(PX)
9B
163
160
164
PB5'
P5
PQ
89
T1
PB1
PB2
PM
(GG)
PG
P1
P2
166
PB2
(GB2)
PO
PN
PB5
T2
PA2
PA1
PA3
168
(G1)
A1
(G2)
X
(R)
A2
T
P
PA4
PB4
PB3
PA3
PA2
PB2
PB1
PA1
5
M
P1
P2
A3
S3
S1
17
24

Symbel	Name
4	Travel spool
5	Bucket spool
6	Boom spool
7	Arm spool
8	Straight travel spool
9A	Cut valve spool (arm side)
9B	Cut valve spool (boom side)
10	Arm conflux spool
11	Boom conflux spool
71A	Travel relief valve
71B	Main relief valve
72	Port relief valve
73	Anti−cavitation valve
89	Sequence valve spool
151	Main circuit
152	Bypass circuit
153	Parallel circuit
154	Main circuit
155	Bypass circuit
156	Parallel circuit
160	Servo pressure circuit
163	Side bypass circuit
164	Side bypass circuit
166	Boom conflux signal circuit
167	Swing signal circuit
168	Arm conflux signal circuit

Fig. 5A Hydraulic circuit diagram

2.2 OPERATION

2.2.1 WHEN IN NEUTRAL

1) Pilot Circuit Operation:

Pilot primary pressure from pump (P3) flows into port (P0) of the control valve.

This pilot pressure is branched off in casing (B) and goes to the RH and LH travel pools.

As the oil passage is blocked by the travel spool when the travel spool is in neutral, no oil flows to the downstream side by-pass circuit.

Therefore, no pressure is supplied to the circuit connected to change-over the by-pass cut-off spool and straight travel valve spool which is divided downstream from the travel spool. So these spools are not changed over.

2) Drive Circuit Operation

Oil discharged from hydraulic pump (P1) flows into the main passage from port (P1) of the control valve.

Oil flowing into the main passage flows to the (right) travel spool.

When the spool is in neutral, as the by-pass passage is not blocked by the spool, oil flowing in passes through the by-pass passage to flow to the travel→boom→bucket spools, and is led to cut-off valve (9B).

As the passage is not blocked at this cut-off valve when in neutral, oil flows into the tank.

Oil discharged from hydraulic pump (P2) flows from port (P2) of the control valve and passes through the by-pass passage of the (left) travel→arm spool, like on the (P1) side, and passes into the tank through the cut-off valve (9A).

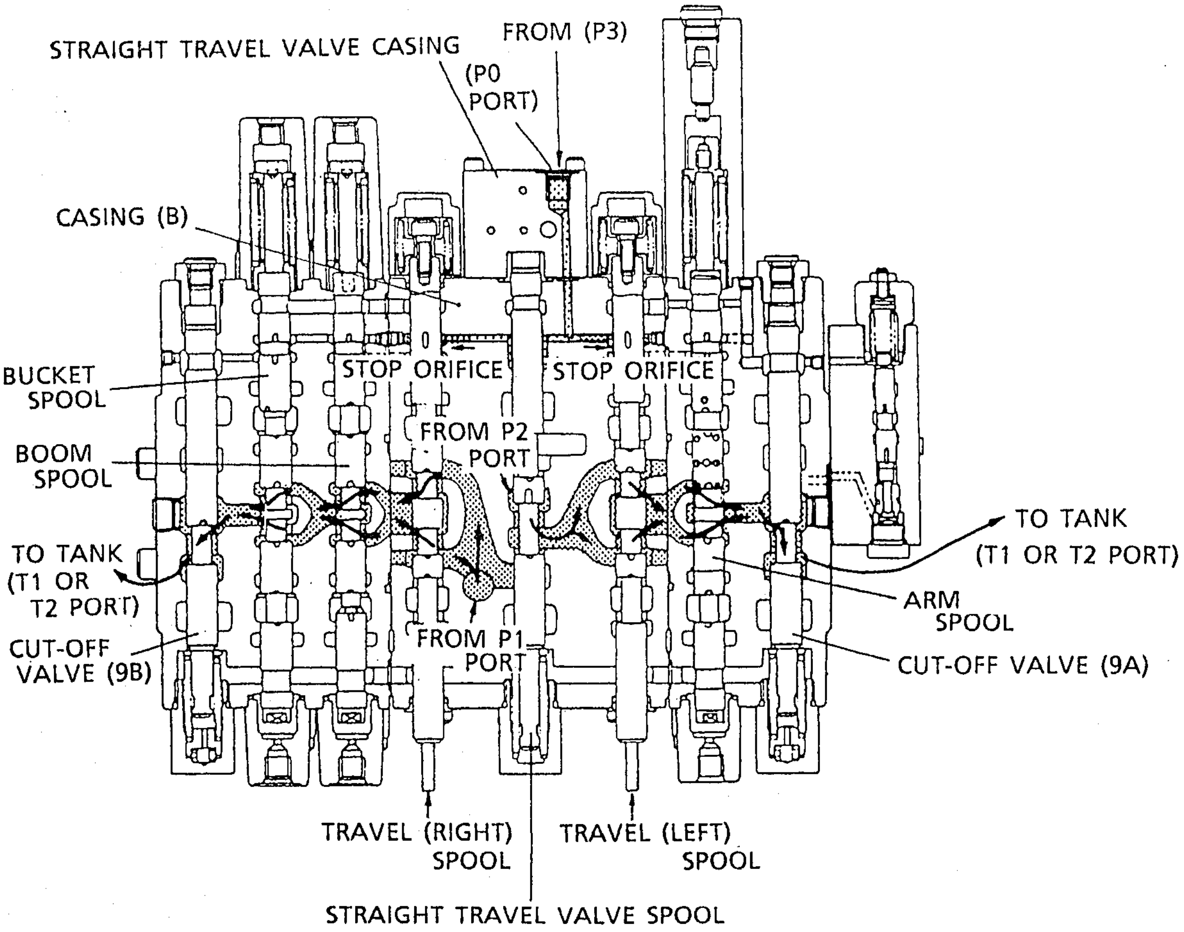

STRAIGHT TRAVEL VALVE CASING
FROM (P3)
(P0 PORT)
CASING (B)
BUCKET SPOOL
BOOM SPOOL
STOP ORIFICE
STOP ORIFICE
FROM P2 PORT
TO TANK (T1 OR T2 PORT)
TO TANK (T1 OR T2 PORT)
ARM SPOOL
CUT-OFF VALVE (9B)
CUT-OFF VALVE (9A)
FROM P1 PORT
TRAVEL (RIGHT) SPOOL
TRAVEL (LEFT) SPOOL
STRAIGHT TRAVEL VALVE SPOOL

Fig. 6 Operation When in Neutral

2.2.2 TRAVEL

(1) Independent Travel Operation

1) Pilot circuit operation :

The pressurized oil that enters port (P0) runs into the side bypass line by the transfer of the travel spool.

It then reaches travel neutral detection ports (PM and PN) and the orifice side.

Since the boom, bucket or arm spool are not changed over at this time, the side bypass circuit downstream of the orifice does not rise.

However, the pressure at ports PM and PN upstream of the orifice rises to the pressure level (P0).

2) Action of the drive circuit : travel (right) side

If the travel spool is operated forward, it is pushed in via the control cable.

Hydraulic oil entering from port (P1) is led to the travel spool from the main passage.

As the travel spool is shifted, the by-pass passage in the travel part is blocked and all the oil from port (P1) flows out through port (B3) to the (right) travel motor.

Return oil from the travel motor flows to the return circuit through port (A3) and flows out through the tank port.

3) Drive circuit operation : (left) travel side

When the travel spool is shifted for forward travel, the travel spool is pushed in by means of a control cable.

Hydraulic oil from port (P2) is led to the travel spool through the straight travel valve passage.

As the travel spool is shifted, the by-pass passage in the travel part is blocked and all the oil from port (P2) flows through port (B4) to the (left) travel motor.

Return oil from the travel motor flows to the return circuit through port (A4) and flows out through the tank port.

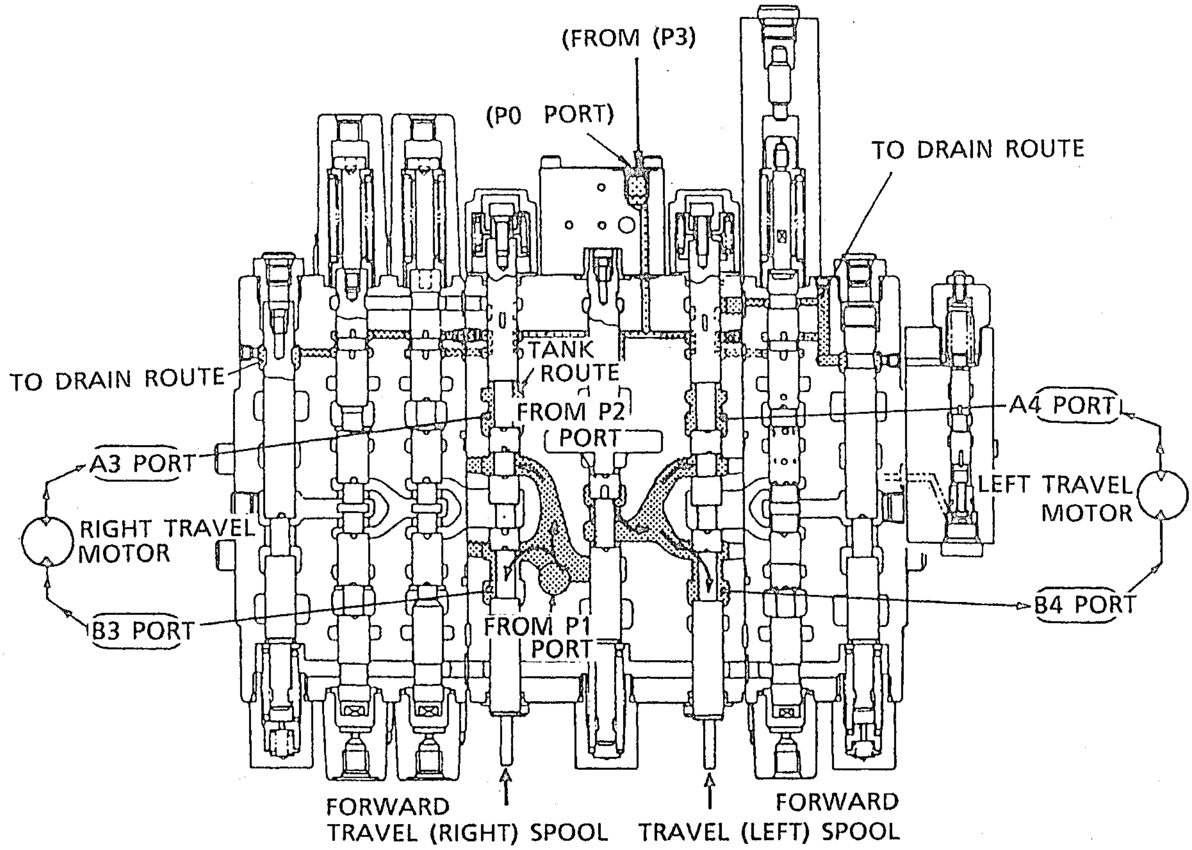

(FROM (P3)
(P0 PORT)
TO DRAIN ROUTE
TO DRAIN ROUTE
TANK ROUTE
FROM P2 PORT
A4 PORT
A3 PORT
LEFT TRAVEL MOTOR
RIGHT TRAVEL MOTOR
B4 PORT
B3 PORT
FROM P1 PORT
FORWARD TRAVEL (RIGHT) SPOOL
FORWARD TRAVEL (LEFT) SPOOL

Fig. 7 Independent Travel Operation

(2) Simultaneous Travel and Other Operations
Example: Raising the boom during forward travel

1) Pilot circuit operation

In this operation, when both the left and right travel spools are pushed in, secondary pilot pressure enters port PB2 of the boom spool, shifting the boom spool.

Oil passing through the side by-pass circuit via the travel spool from port (P0) is blocked by the boom spool as the travel spool is shifted; pressure in the side by-pass circuit rises, changing over the straight travel valve spool; at the same time oil flows into the pilot chamber of cut-off valve 9A via the shuttle valve, changing over cut-off valve 9A

Secondary pilot pressure for raising the boom is divided (branch point PB2″) and changes over the boom confluence valve spool.

(Refer to Boom Hoist Operation.)

2) Main circuit operation

Hydraulic oil entering port (P2) flows into the check valve (CH1) side as the straight travel valve spool is changed over, and continues into the boom spool through the parallel passage inside the main body. Hydraulic oil flows from port (B2) to the head side of the boom cylinder as the boom spool is changed over.

(The boom cylinder rod side is connected to the tank through port A2.)

Hydraulic oil entering port (P1) is led to the left and right travel spools as the straight travel spool is changed over, and then flows to the travel motors through the respective outlet ports (B3 and B4).

When travel and other operations are carried out simultaneously, hydraulic oil from port (P1) is divided and distributed to both travel spools.

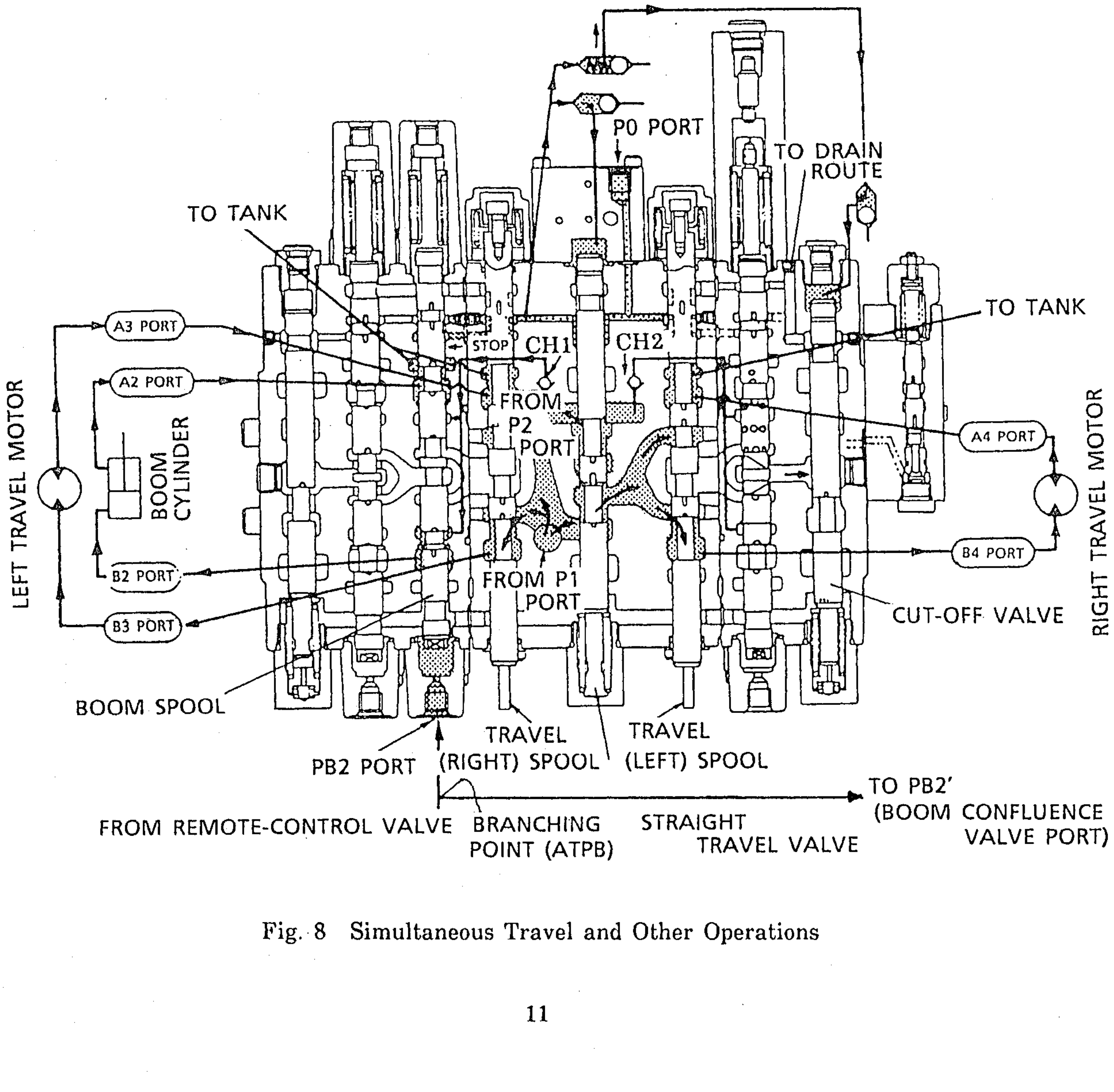

P0 PORT
TO DRAIN ROUTE
TO TANK
TO TANK
A3 PORT
A2 PORT
STOP
CH1
CH2
FROM P2 PORT
A4 PORT
LEFT TRAVEL MOTOR
BOOM CYLINDER
RIGHT TRAVEL MOTOR
B2 PORT
B3 PORT
FROM P1 PORT
B4 PORT
CUT-OFF VALVE
BOOM SPOOL
TRAVEL (RIGHT) SPOOL
TRAVEL (LEFT) SPOOL
PB2 PORT
TO PB2′ (BOOM CONFLUENCE VALVE PORT)
FROM REMOTE-CONTROL VALVE
BRANCHING POINT (ATPB)
STRAIGHT TRAVEL VALVE

Fig. 8 Simultaneous Travel and Other Operations

2.2.3 BUCKET OPERATION

(1) Bucket Digging

1) When digging with the bucket, secondary pressure from the remote－control valve enters port (PA1) and shifts the bucket spool. Incidentally, the bucket has no confluence function for digging/dumping.

2) Main circuit operation:
Hydraulic oil entering port (P1) passes through the by－pass circuit of the travel spool and boom spool to reach the bucket spool, but the by－pass circuit is blocked if the bucket spool is shifted. Therefore, oil branching to the parallel circuit from the travel spool pushes open load check valve 1, passes through the U-shaped passage, and is led to the bucket spool. It flows out of port (B1) via the notch on the outer circumference of the bucket spool.
Return oil from port (A1) flows to the tank.
Hydraulic oil entering port (P2) reaches cut-off valve 9A through the by－pass circuit of the travel→arm spools.
As this cut－off valve 9A does not perform confluence change－over, hydraulic oil from port (P2) flows to the tank.

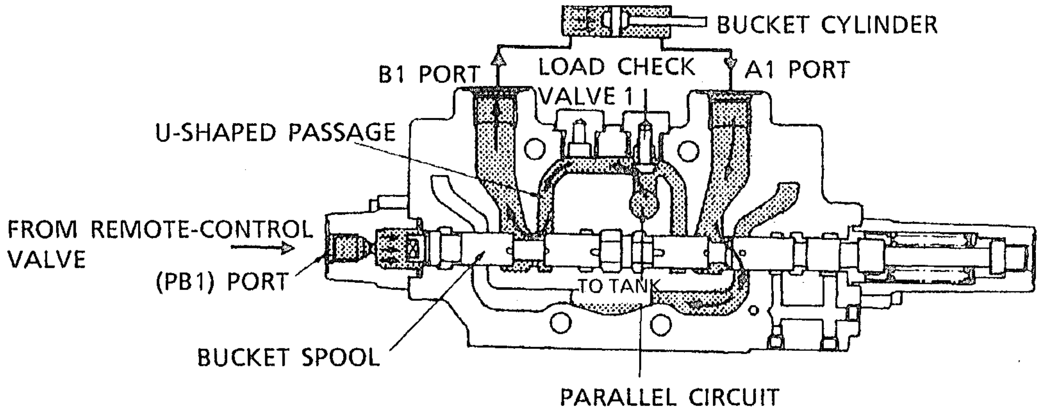

BUCKET CYLINDER
B1 PORT
LOAD CHECK VALVE 1
A1 PORT
U-SHAPED PASSAGE
FROM REMOTE-CONTROL VALVE
(PB1) PORT
TO TANK
BUCKET SPOOL
PARALLEL CIRCUIT

Fig. 9 Bucket Digging Operation

(2) Bucket Dumping

1) Pilot circuit operation:
When dumping the bucket, secondary pressure from the remote－control valve enters port (PA1) and shifts the bucket spool.
Incidentally, the bucket is not fitted with a confluence function for digging/dumping.

2) Main circuit operation:
Hydraulic oil entering port (P1) passes through the by－pass circuit of the travel spool and boom spool to reach the bucket spool, the by－pass circuit is blocked if the bucket spool is shifted. Therefore, oil branching to the parallel circuit from the travel spool pushes open load check valve 1, passes through the U－shaped passage, and is led to the bucket spool. It flows out of port (A1) via the notch on the outer circumference of the bucket spool.
Return oil from port (B1) flows to the tank.
Hydraulic oil entering port (P2) reaches cut－off valve 9A through the by－pass circuit of the travel→arm spool.
As this cut－off valve 9A does not perform confluence change－over, hydraulic oil from port (P2) flows to the tank.

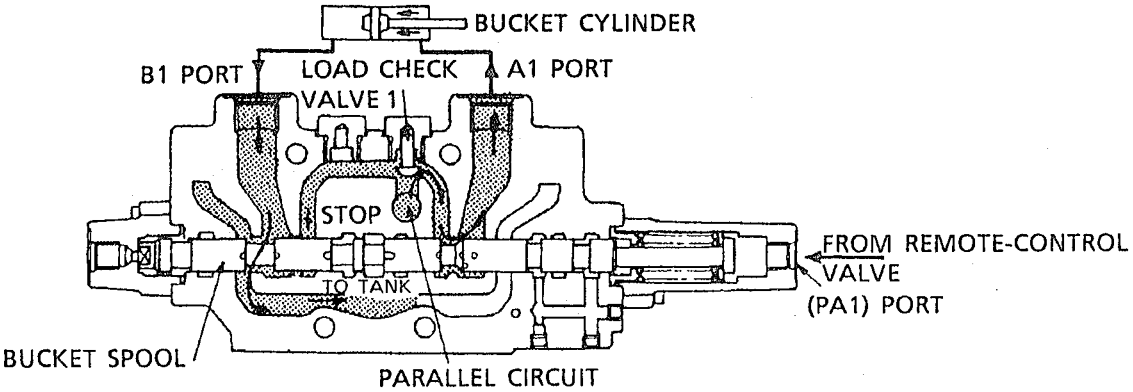

BUCKET CYLINDER
B1 PORT
LOAD CHECK VALVE 1
A1 PORT
STOP
TO TANK
FROM REMOTE-CONTROL VALVE
(PA1) PORT
BUCKET SPOOL
PARALLEL CIRCUIT

Fig. 10 Bucket Dumping Operation

2.2.4 BOOM OPERATION

(1) Raising the Boom

1) Pilot circuit operation :

When the boom is raised, secondary pressure from the remote－control valve enters port (PB2) and shifts the boom spool.

As the hydraulic oil from port (P0) is blocked by the travel spool, the side by－pass circuit pressure does not rise and so the straight travel valve spool is not changed over.

Secondary pressure from the remote－control valve is divided and led to port (PB2′) after which it changes over the boom confluence valve and at the same time passes through the 2 shuttle valves builtin in to the valve and changes over cut－off valve 9A.

2) Main circuit operation

Hydraulic oil entering port (P1) passes through the by－pass circuit of the travel spool to reach the boom spool, but as the by－pass circuit is blocked as the bucket spool is shifted, the oil branches to the parallel circuit from the travel spool and pushes open load check valve 1, passes through the U－shaped passage, and is led to the boom spool (section E－E). It flows to port (B2) through the notch in the outer circumference of the boom spool.

Hydraulic oil entering port (P2) passes through the by－pass circuit of the travel→arm spools to reach cut－off valve 9A, but as it is blocked as cut－off valve 9A is changed over, the oil branches to the parallel circuit from the travel spool and flows into the confluence passage as the boom confluence valve is changed over. It then pushes open load check valve 2, passes through the U－shaped passage, and flows through port (B2) to be led to the boom cylinder head side.

Return oil on the boom cylinder rod side flows to the return oil circuit through port (A2) and flows out through the tank (T) port.

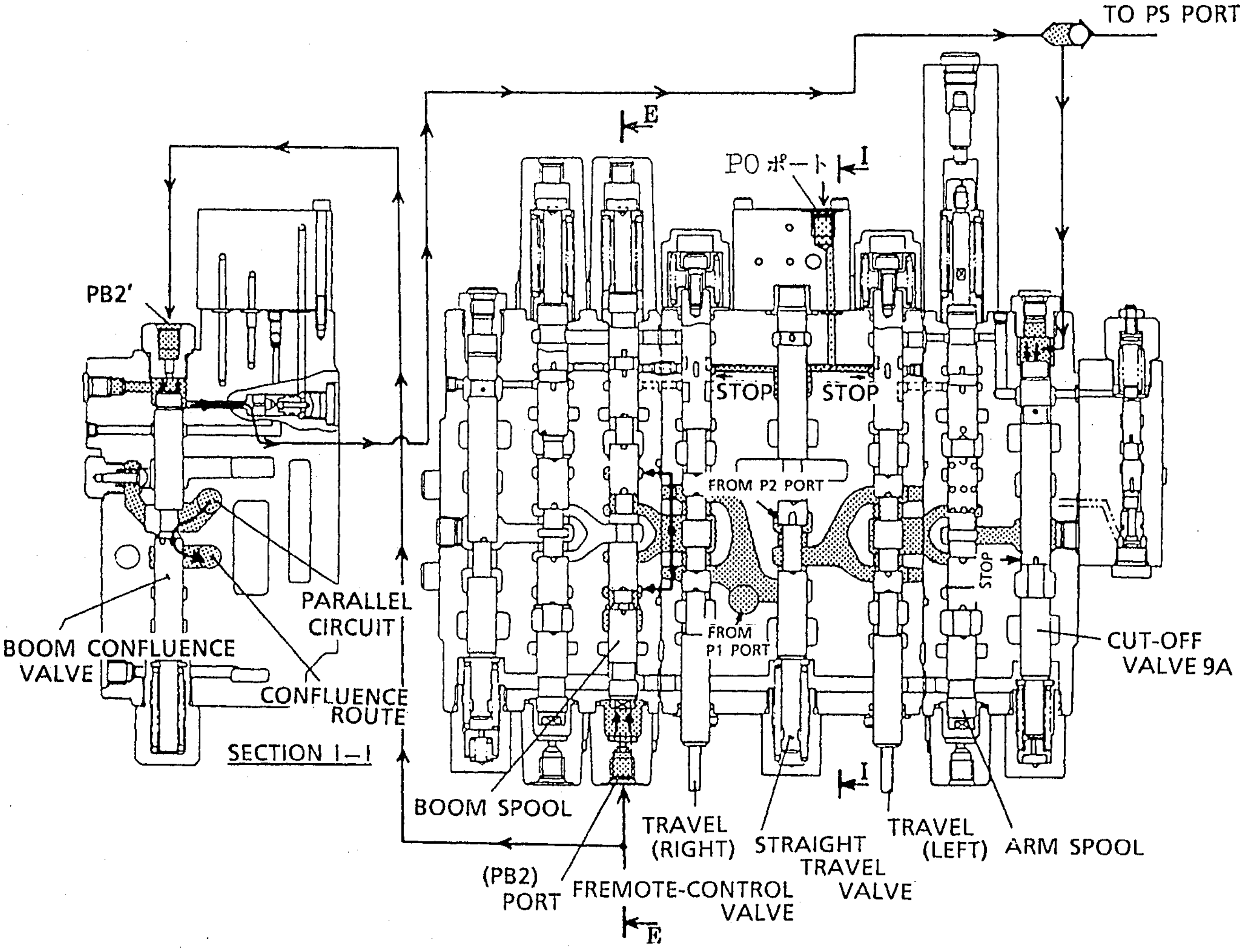
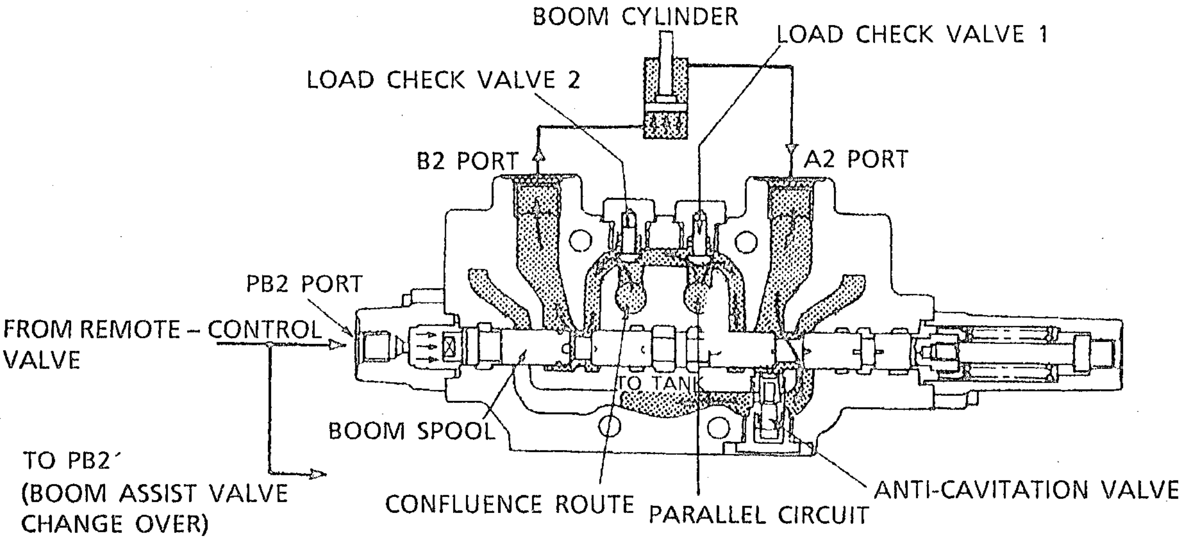

TO PS PORT
E
PO ポート
I
PB2′
STOP
STOP
FROM P2 PORT
STOP
FROM P1 PORT
PARALLEL CIRCUIT
BOOM CONFLUENCE VALVE
CONFLUENCE ROUTE
SECTION I－I
CUT-OFF VALVE 9A
BOOM SPOOL
I
TRAVEL (RIGHT)
STRAIGHT TRAVEL VALVE
TRAVEL (LEFT)
ARM SPOOL
(PB2) PORT
FREMOTE-CONTROL VALVE
E

Fig. 11 Boom Raising Operation


BOOM CYLINDER
LOAD CHECK VALVE 1
LOAD CHECK VALVE 2
B2 PORT
A2 PORT
PB2 PORT
FROM REMOTE - CONTROL VALVE
TO TANK
BOOM SPOOL
TO PB2′ (BOOM ASSIST VALVE CHANGE OVER)
CONFLUENCE ROUTE
PARALLEL CIRCUIT
ANTI-CAVITATION VALVE

SECTION E - E

Fig. 12 Boom Lowering Operation

(2) Lowering the Boom

1) Pilot circuit operation:

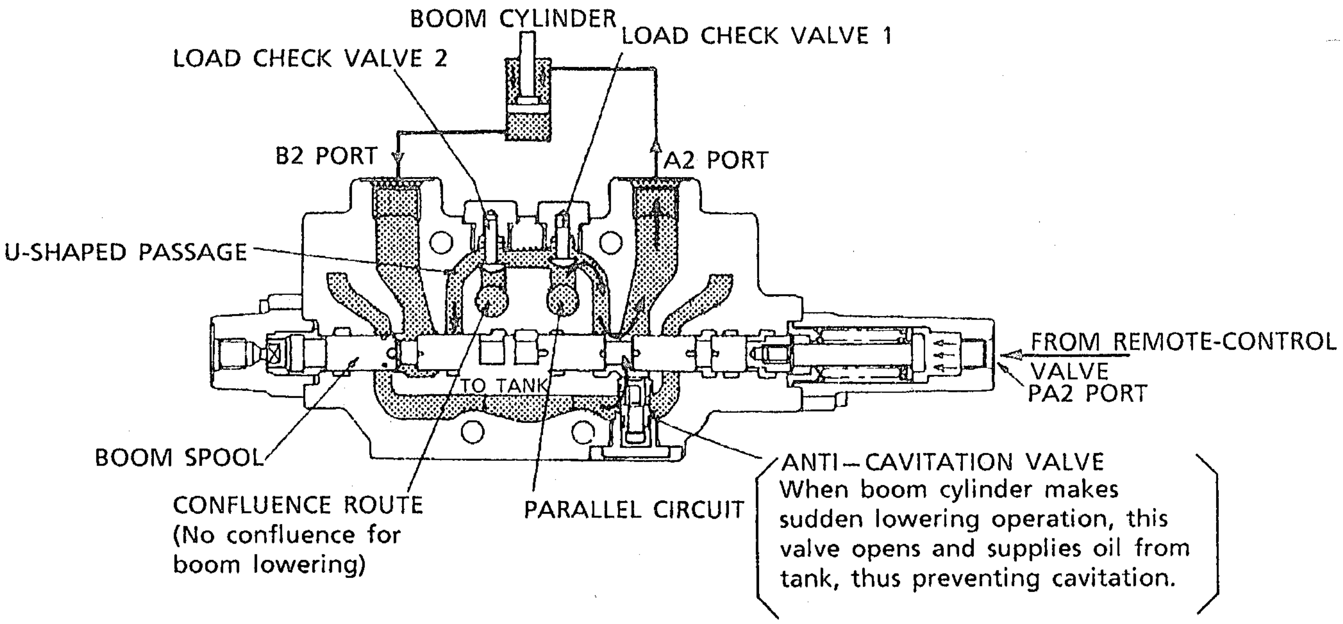
When lowering the boom, secondary pressure from the remote-control valve enters port (PA2) and shifts the boom spool. As there is no confluence for lowering the boom, there is no branching from port (PA2).

2) Main circuit operation:

Hydraulic oil entering port (P1) passes through the by-pass circuit of travel spool to reach the boom spool, but as the by-pass circuit is blocked when the boom spool is shifted, the oil branches to the parallel circuit from the travel spool, after which it pushes open load check vale 1, passes through the U-shaped passage, and is to the boom spool.It flows out to port (A2) through the notch in the outer circumference of the boom spool.

Hydraulic oil entering port (P2) passes through the by-pass circuit of the travel→arm spools, and reaches cut-off valve 9A.

As this cut-off valve 9A does not perform confluence when lowering the boom, there is no change-over and the return oil from port P2 flows to the tank.


BOOM CYLINDER
LOAD CHECK VALVE 1
LOAD CHECK VALVE 2
B2 PORT
A2 PORT
U-SHAPED PASSAGE
FROM REMOTE-CONTROL VALVE
PA2 PORT
TO TANK
BOOM SPOOL
CONFLUENCE ROUTE (No confluence for boom lowering)
PARALLEL CIRCUIT
ANTI-CAVITATION VALVE

When boom cylinder makes sudden lowering operation, this valve opens and supplies oil from tank, thus preventing cavitation.

Fig. 13 Boom Raising Operation

2.2.5 ARM OPERATION

(1) Extending the Arm

1) Pilot circuit operation:

When extending the arm, secondary pressure from the remote-control valve enters port (PA5) and shifts the arm spool.

As hydraulic oil from port (P0) is blocked by the travel spool, the side by-pass circuit pressure does not rise and the straight travel valve spool is not changed over.

Secondary pressure from the remote-control valve is divided and enters port (PG) by means of the shuttle valve, after which it changes over the arm confluence valve and at the same time passes through the 9B shuttle vales built-in to the valve to change over cut-off valve 1 (see Section G-G)

2) Main circuit operation:

Hydraulic oil entering port (P2) passes through the by-pass circuit of the travel spool from the straight travel valve passage to reach the arm spool, but the by-pass circuit is blocked when the arm spool is shifted so the oil branches to the parallel circuit from the travel spool, after which it pushes open load check valve 1, passes through the U-shaped passage, and is led to the arm spool (see Section K-K).

It flows to port (A5) through the notch in the outer circumference of the arm spool.

Hydraulic oil entering port (P1) passes through the by-pass circuit of the travel →boom → bucket spools but as it is blocked when cut-off valve 9B is changed over, the oil branches to the parallel circuit from the travel spool after which it flows into the confluence passage as the arm confluence valve is changed over, pushes open load check valve 2, passes through the U-shaped passage, flowing through port (A5) to be led to the arm cylinder rod side.

Return oil on the arm cylinder head side flows to the return oil circuit through port (B5) and flows out through the tank (T) port.

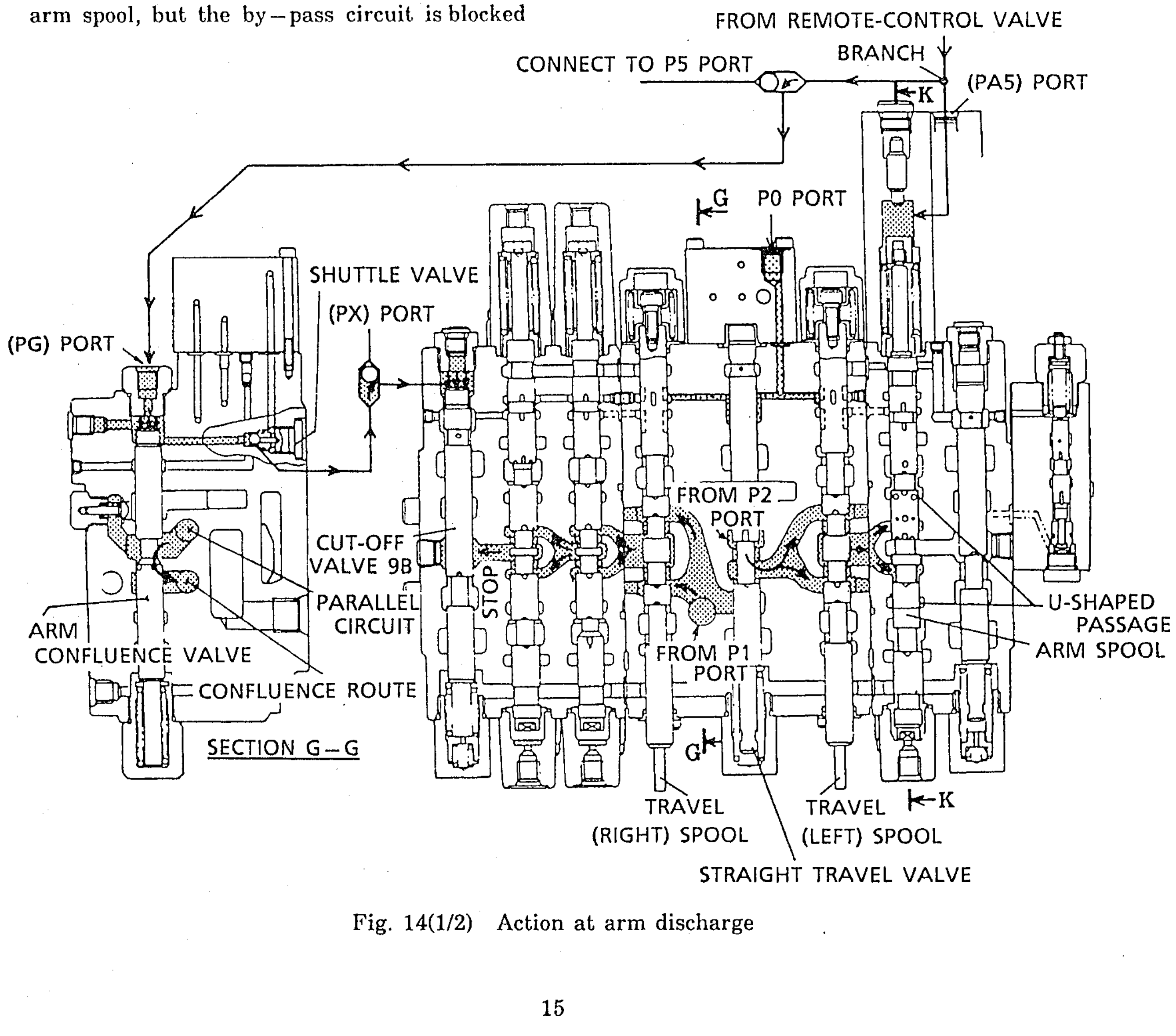
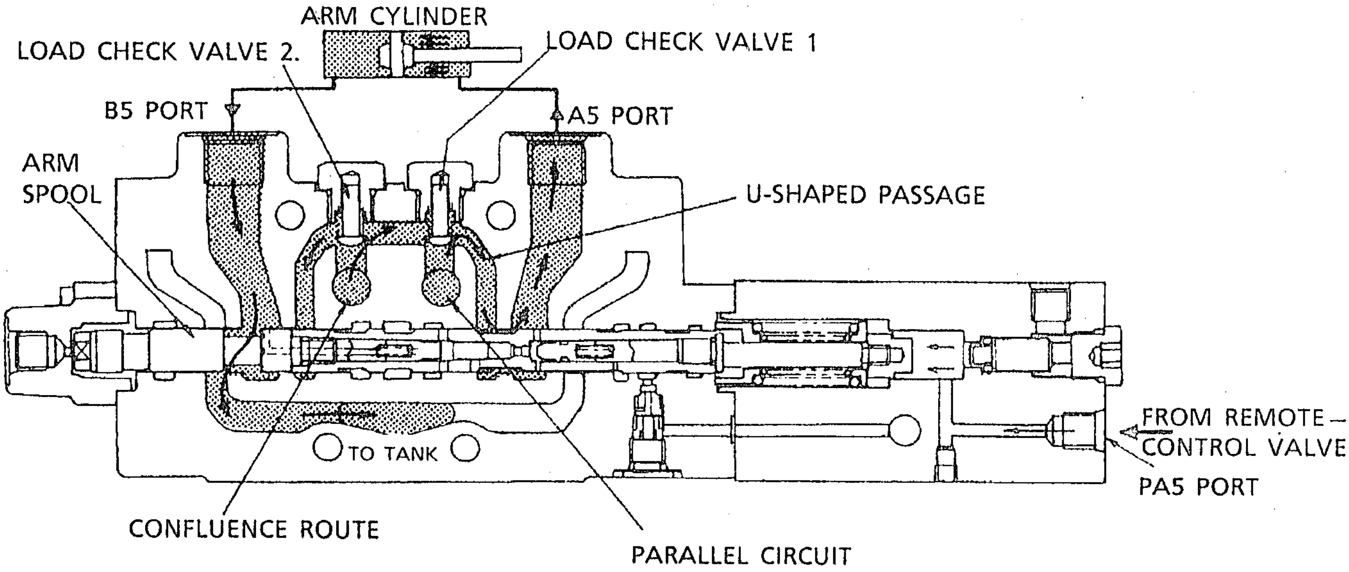

FROM REMOTE-CONTROL VALVE
BRANCH
CONNECT TO P5 PORT
(PA5) PORT
K
G
P0 PORT
SHUTTLE VALVE
(PX) PORT
(PG) PORT
FROM P2 PORT
CUT-OFF VALVE 9B
PARALLEL CIRCUIT
STOP
ARM CONFLUENCE VALVE
CONFLUENCE ROUTE
FROM P1 PORT
SECTION G-G
G
U-SHAPED PASSAGE
ARM SPOOL
TRAVEL (RIGHT) SPOOL
TRAVEL (LEFT) SPOOL
K
STRAIGHT TRAVEL VALVE

Fig. 14(1/2) Action at arm discharge


ARM CYLINDER
LOAD CHECK VALVE 2.
LOAD CHECK VALVE 1
B5 PORT
A5 PORT
ARM
SPOOL
U-SHAPED PASSAGE
TO TANK
FROM REMOTE–
CONTROL VALVE
PA5 PORT
CONFLUENCE ROUTE
PARALLEL CIRCUIT

SECTION K–K

Fig. 14(2/2) Arm Extend Operation

(2) Arm Digging (Light Load)

1) Pilot circuit operation:

When digging with the arm, secondary pressure from the remote-control valve enters port (PB5) and shifts the arm spool.

As the hydraulic oil from port (P0) is blocked by the travel spool, just like when extending the arm, the side by-pass circuit pressure does not rise and the straight travel valve spool is not changed over (see Fig. 15).

On the other hand, the pressurized oil branched from port (P0) is admitted to port (PQ) of the arm conflux sequence valve and port (PQ′) on the arm return spring side at the same time. Since the sequence valve does not work below 120kgf/cm^2 (1710 psi), the piston is held in the position shown in the figure below.

2) Main circuit operation

As the arm confluence valve and cut-off valve 9B are not changed over, hydraulic oil from port (P1) passes through the by-pass circuit of the travel →boom→bucket spools to reach cut-off valve 9B, where it is led to the tank through the notch in cut-off valve 9B.

The hydraulic oil entering from port (P2) passes from the straight travel valve to the by-pass circuit of the travel spool to reach the arm spool, but the by-pass circuit is blocked when the arm spool is shifted, so the oil branches to the parallel circuit from the travel spool, after which it pushes open load check valve 1, passes through the U-shaped passage, and is led to the arm spool. It flows to port (B5) through the notch in the outer circumference of the arm spool.

Hydraulic oil returning to port (A5) enters the spool through hole (a) in the outer circumference of the arm spool and some of this oil pushes open check valve (1) built-in to the spool, after which it flows out of hole (b) in the outer circumference to flow backwards through the U-shaped passage into port (B5).

Some of this return oil also pushes open check valve (2) built-in to the spool to escape to the tank side, but as this passage is small, most of this oil flows to the confluence side. This is called the "arm regeneration function".

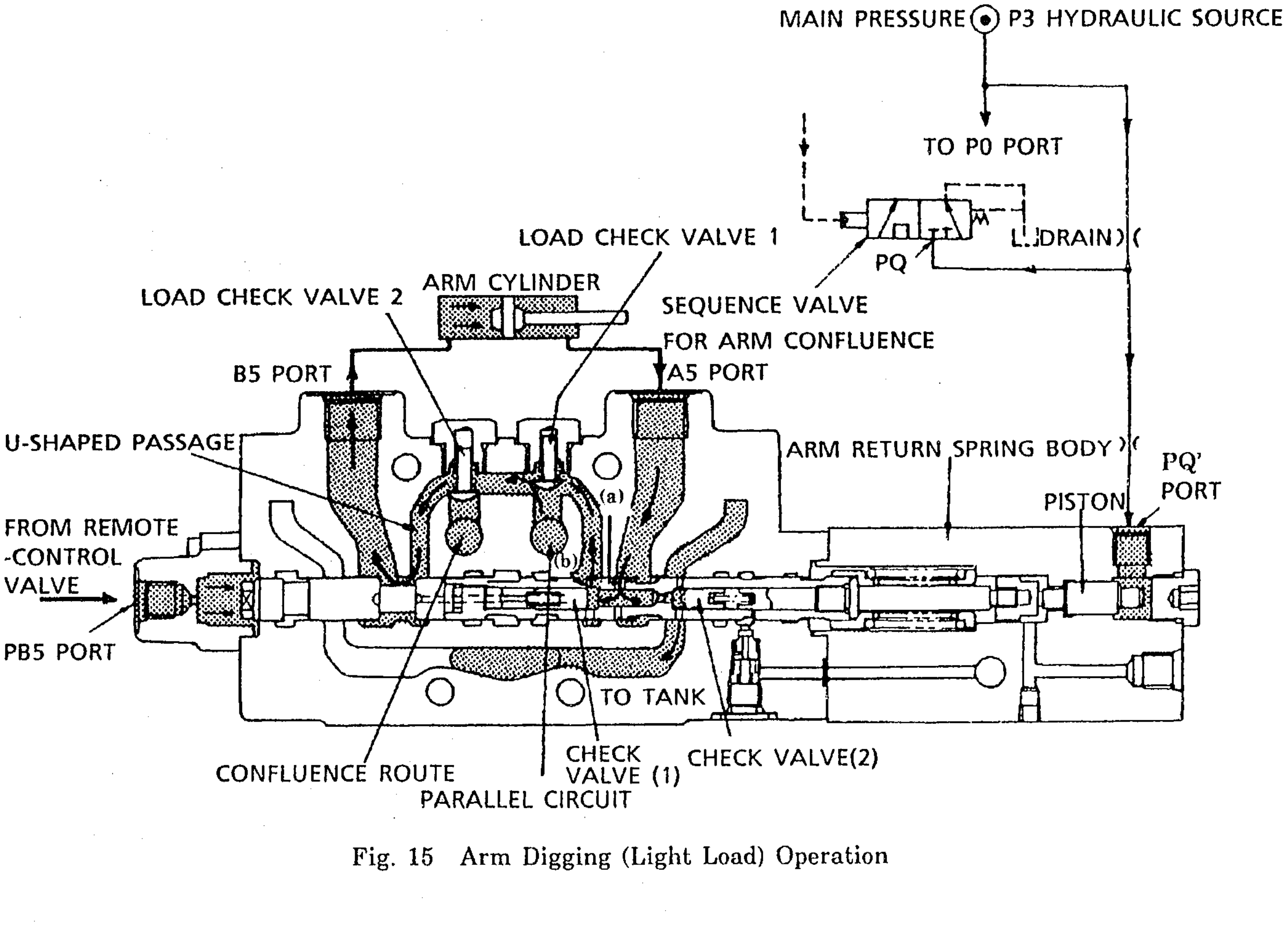

MAIN PRESSURE
P3 HYDRAULIC SOURCE
TO P0 PORT
DRAIN
LOAD CHECK VALVE 1
PQ
ARM CYLINDER
LOAD CHECK VALVE 2
SEQUENCE VALVE
FOR ARM CONFLUENCE
B5 PORT
A5 PORT
U-SHAPED PASSAGE
ARM RETURN SPRING BODY
PQ'
PORT
PISTON
(a)
(b)
FROM REMOTE
-CONTROL
VALVE
PB5 PORT
TO TANK
CONFLUENCE ROUTE
CHECK
VALVE (1)
CHECK VALVE(2)
PARALLEL CIRCUIT

Fig. 15 Arm Digging (Light Load) Operation

(3) Arm Digging Operation (Heavy Load)

1) Pilot circuit operation :

When digging with the arm, secondary pressure from the remote-control valve enters port (PB5) and shifts the arm spool.

As the hydraulic oil from port (P0) is blocked by the travel spool, just like when extending the arm, side by-pass circuit pressure does not rise and the straight travel valve spool is not changed over.

Regarding the hydraulic oil branched through port (PQ), from (PQ´), pressure is led fromport (P0) of the arm confluence sequence valve and port (PQ´) of the arm return valve casing.

When digging with the arm under a heavy load, a pressure increases on the arm cylinder head side it increases in the main circuit and changes over the arm confluence sequence spool at 120kgf/cm^2 (1710 psi).

As the hydraulic oil inside port (PQ´) flows out to the drain as the arm confluence sequence spool is changed over, the pressure inside port (PQ´) on the arm return spring casing side drops.

Due to the drop in pressure in port (PQ´), the arm spool is stroked beyond the position under light load.

The remote control secondary pressure branching from port (PB5) as the arm confluence sequence spool is changed over passes through port (PB5´) → port (P5) of the sequence valve, after which it enters port (PG) by means of the shuttle valve, changing over the arm confluence valve and at the same time passes through the 2 shuttle valves built-in to the valve, and changes over cut-off valve 9B.

2) Main circuit operation :

Hydraulic oil entering port (P2) follows the same flow path as when digging with the arm under a light loag mentioned above. The only difference is that the hydraulic oil from port (P1) enters the confluence passage of the arm change-over section when the arm confluence valve and cut-off valve 9B are changed over. There it pushes open check valve (2) and passes through the U-shaped passage, to be supplied to the arm cylinder head side from port (B5) (see Section K-K).

Return oil on the arm cylinder rod side is led to the arm spool through port (A5) and all the oil flows out to the tank passage side through the notch in the spool.

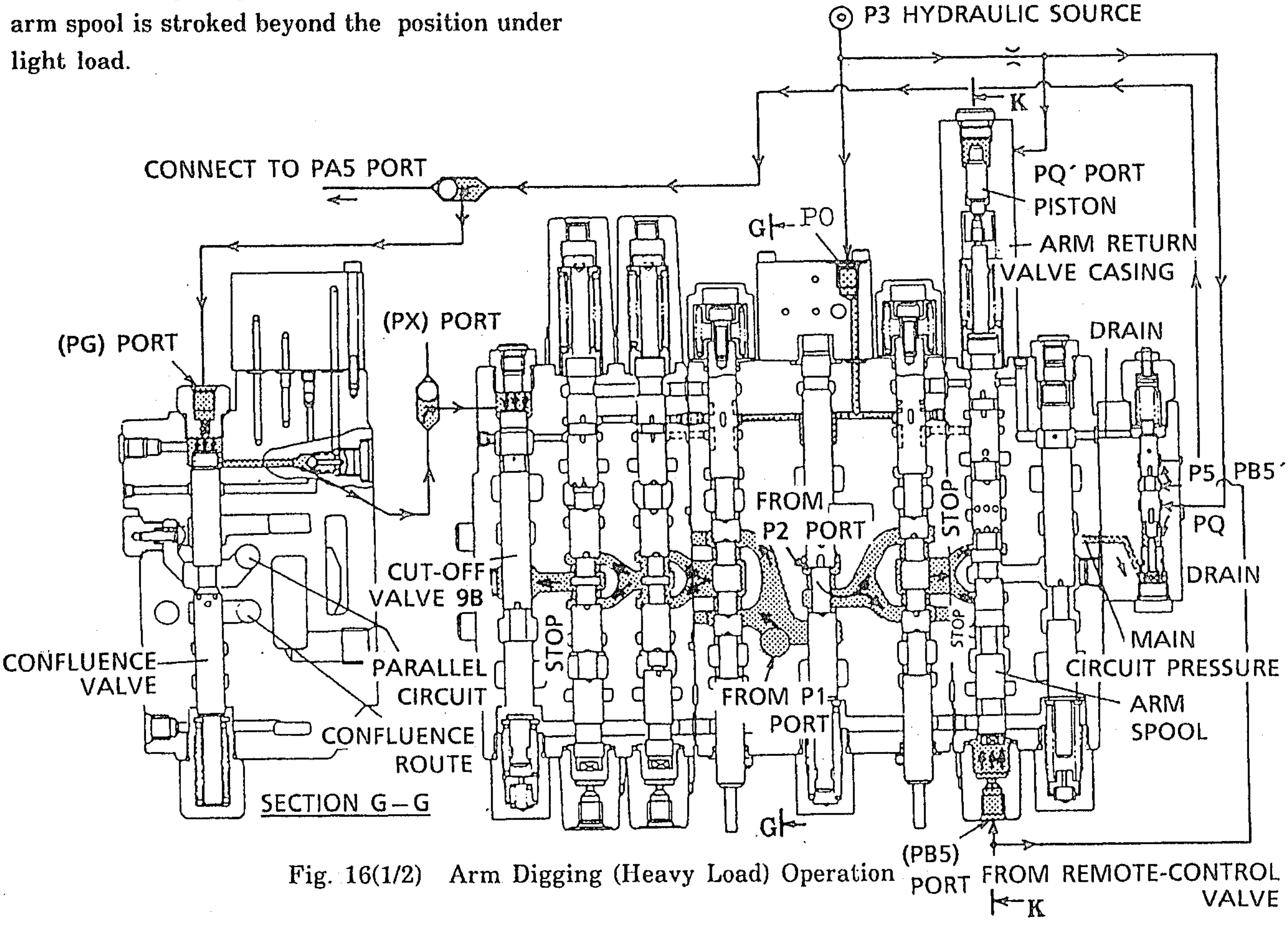
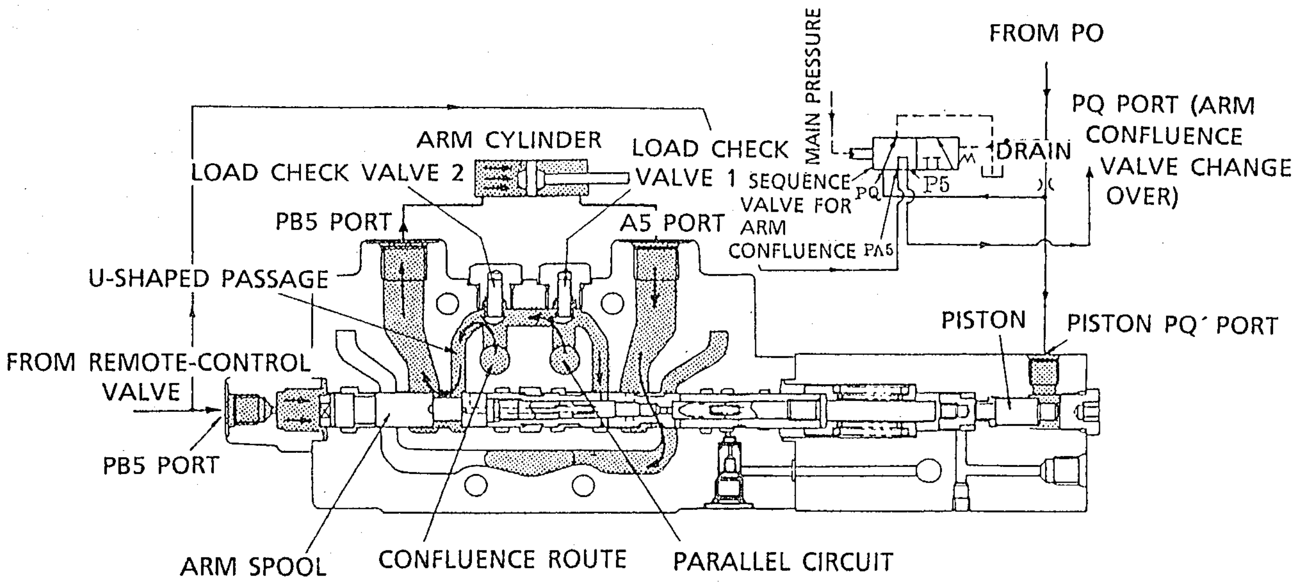

P3 HYDRAULIC SOURCE
K
CONNECT TO PA5 PORT
PQ´ PORT
PISTON
G
PO
ARM RETURN
VALVE CASING
(PX) PORT
DRAIN
(PG) PORT
P5
PB5´
PQ
DRAIN
FROM
P2 PORT
STOP
CUT-OFF
VALVE 9B
STOP
STOP
MAIN
CIRCUIT PRESSURE
PARALLEL
CIRCUIT
CONFLUENCE
VALVE
FROM P1
PORT
ARM
SPOOL
CONFLUENCE
ROUTE
SECTION G-G
G
(PB5)
PORT
FROM REMOTE-CONTROL
VALVE
K

Fig. 16(1/2) Arm Digging (Heavy Load) Operation


MAIN PRESSURE
FROM PO
PQ PORT (ARM CONFLUENCE VALVE CHANGE OVER)
ARM CYLINDER
LOAD CHECK VALVE 1
LOAD CHECK VALVE 2
DRAIN
SEQUENCE VALVE FOR ARM CONFLUENCE
PQ
P5
PA5
PB5 PORT
A5 PORT
U-SHAPED PASSAGE
PISTON
PISTON PQ′ PORT
FROM REMOTE-CONTROL VALVE
PB5 PORT
ARM SPOOL
CONFLUENCE ROUTE
PARALLEL CIRCUIT

SECTION K–K

Fig. 16(2/2) Arm Digging (Heavy Load) Operation

2.2.6 SIMULTANEOUS ARM DIGGING AND SWINGING

1) Pilot circuit operation:

Because arm operations have been explained above, they will be omitted here.

Remote–control secondary pressure for the swing valve, upon entering port (PS) and changing over cut–off valve 9A passes through the throttle of the logic valve and enters the arm spool where it closes check valve 2 built–in to the spool.

2) Main circuit operation:

The swing control valve is a motor–mounted exclusive valve. The pump port is connected to port (P) of this valve, constituting a parallel circuit with the arm operating part.

When digging with the arm and swinging arm carried out at the same time, because the operation under less load is given first priority, a logic valve and check valve (2) are built in to start the swing operation first.

As the return pilot pressure from port (PS) closes check valve (2), return oil on the arm cylinder rod side is throttled and goes to the tank. This causes the pressure on the arm cylinder head side to rise above swing operating pressure, so the greater volume of hydraulic oil is supplied to the swing side.

This is called the "swing priority circuit".

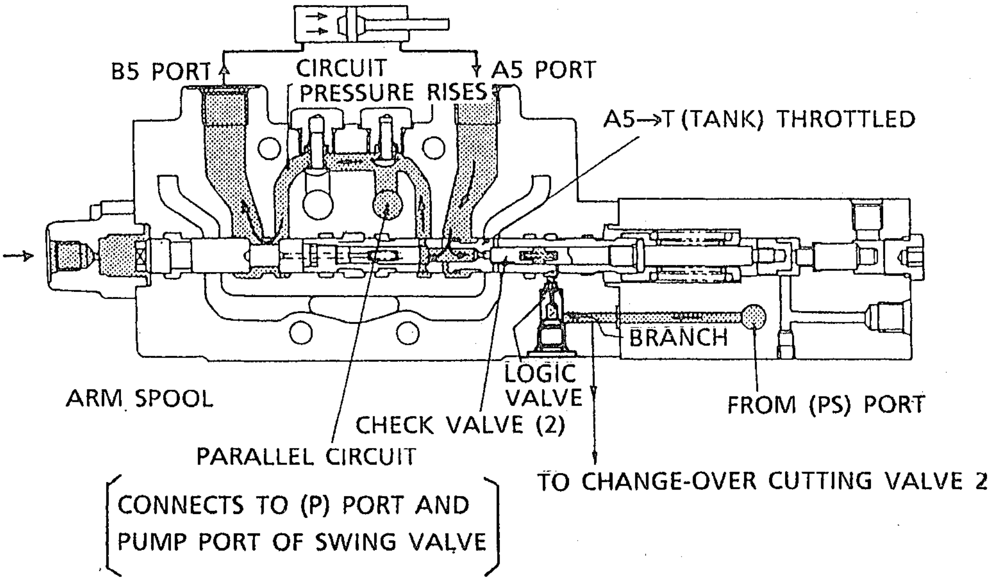

B5 PORT
CIRCUIT PRESSURE RISES
A5 PORT
A5→T (TANK) THROTTLED
BRANCH
ARM SPOOL
LOGIC VALVE
FROM (PS) PORT
CHECK VALVE (2)
PARALLEL CIRCUIT
CONNECTS TO (P) PORT AND PUMP PORT OF SWING VALVE
TO CHANGE-OVER CUTTING VALVE 2

Fig. 17 Simultaneous Arm Digging and Swing Operations

2.2.7 FUNCTION OF MAIN RELIEF VALVE

The main relief valve is fitted between the high pressure passage in the main circuit and the low pressure passage in the tank side and functions as follows.

1) Hydraulic pressure oil is felled up in the inside chamber A through restriction (B) of plunger (main valve) and seats plunger against socket.

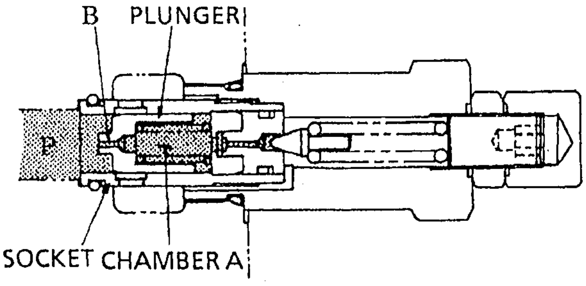


Fig. 18

2) When the pressurized oil of main circuit (P) reaches at a set pressure of spring, it passes through restrictor hole (C), forces poppet open, and runs into tank passage (T) through passage (D).

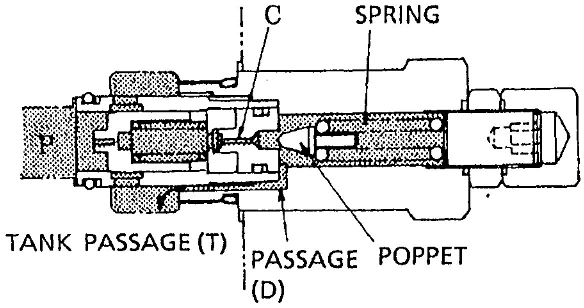


Fig. 19

3) Opening of poppet causes the pressure in chamber A to fall and plunger to open. As the result, the pressurized oil at main circuit (P) run into tank passage (T).

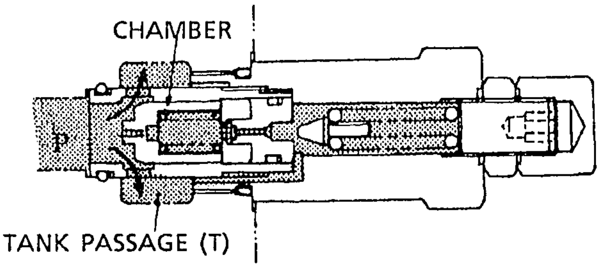


Fig. 20

4) When the pressure in main circuit (P) falls down and reaches below a set pressure of spring, the plunger is pushed against seat by spring force. As the result, the main relief valve return to the state in Fig. 20.

2.2.8 FUNCTION OF PORT RELIEF VALVE

The port relief valve is fitted between the cylinder port and low pressure passage in the tank side. It serves as a relief valve and also an anti-cavitation check valve, providing the following functions.

(1) Function of Relief Valve

1) The hydraulic oil is filled up in the inner chamber A through restriction (B) in plunger (main valve), thus seating plunger against socket and socket against casing seat positively.

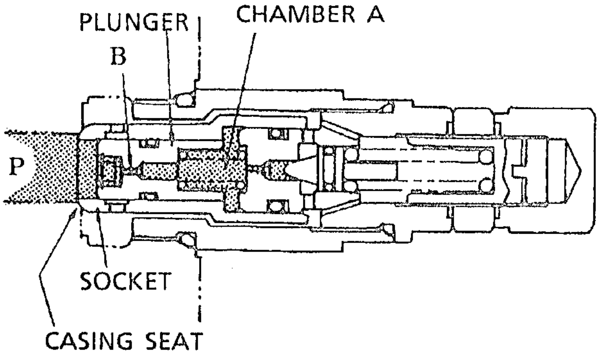

PLUNGER
B
CHAMBER A
P
SOCKET
CASING SEAT

Fig. 21

2) When the hydraulic pressure at port (P) reaches a set pressure of spring, it forces poppet open through restriction (C), runs around socket and finally arrives at tank passage (T) through drilled hole (D).

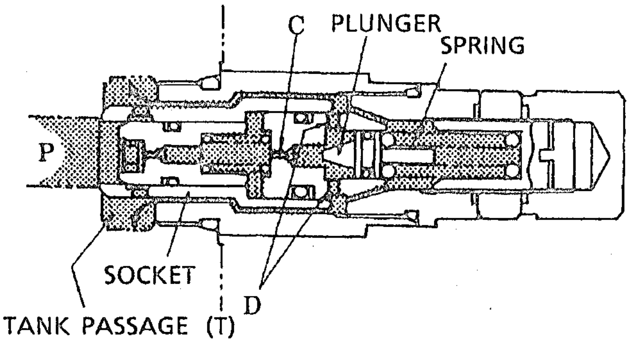

C
PLUNGER
SPRING
P
SOCKET
D
TANK PASSAGE (T)

Fig. 22

3) Opening of poppet causes the hydraulic pressure in chamber A to fall and opens plunger. As the result the hydraulic oil at port (P) runs directly to tank passage (T).

4) When the pressure in port (P) falls down and reaches below a set pressure of spring, the plunger is pushed against seat by spring force. As the result, the port relief valve return to the state in Fig. 23.

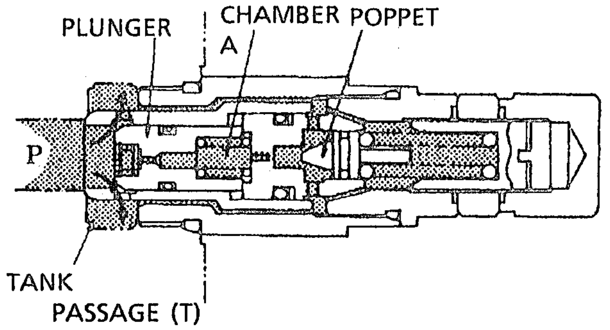

PLUNGER
CHAMBER
A
POPPET
P
TANK
PASSAGE (T)

Fig. 23

5) Anti-cavitation check valve operation hydraulic oil is supplied from low-pressure passage (T) when negative pressure is generated at port (P).

When the pressure in low-pressure passage (T) exceeds the pressure in port (P), enough force to push up the socket is applied. As the gap between the seat and socket gets larger, oil flows from low-pressure passage (T) to port (P), filling up the space.

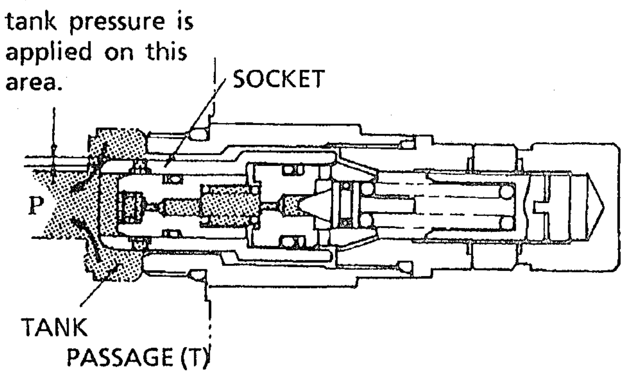

Socket raised as
tank pressure is
applied on this
area.
SOCKET
P
TANK
PASSAGE (T)

Fig. 24

3. DISASSEMBLY AND ASSEMBLY

3.1 GENERAL PRECAUTIONS

1) Since all hydraulic components are precision machined, a particularly clean place must be chosen in executing disassembly and assembly.
2) When handling control valves, exercise full care so as not to allow dust, sand soil to intrude inside.
3) When dismantling a control valve from the machine, put a plug to each port, recheck that caps are fitted throughout before dismantling and clean the outside of the assembly. For operation, use a suitable work bench and place a clean paper sheet or a rubber matress on it.
4) When carrying or moving the control valve, use suspending bolts screwed into the proper suspending bolt holes or have several people support the body.
Handle it gently, and never put pressure on a lever, exposed spool or end cover.
5) After disassembly and assembly of components, various tests (relief characteristics, leak test, overload valve setting, flow resistance check, etc.) should preferably be executed, but to execute such tests, special test equipment are required. For this reason, avoid dismantling such components that can be disassembled technically but can not be tested because test equipment are unavailable. Get clean cleaning oil, hydraulic oil and grease beforehand.

3.2 TOOLS

Before disassembling the control valve, get the following tools beforehand.

Table 6

Sym.	Tools name	Q' ty	Remarks
a	Vice stand	1 set	
b	Cushion	2	For vice (copper plate)
c	Allen key wrench	1 each	2,4,5,6,8,10mm(0.08″, 0.16″,0.20″,0.24″,0.31″0.39″)
d	Spanner	1 each	10,13,21,26,32mm (0.39″,0.51″,0.83″,1.0″,1.3″)
e	Socket wrench	1 each	21,26mm(0.83″,1.0″)
f	Loctite #242	1	
g	Spatula	1 pc.	
h	Screwdriver	1 pc.	For minus

3.3 DISASSEMBLY

The figures in parentheses after part names in the instructions correspond to those in construction drawings.

1) Place the control valve on a work bench with the cylinder ports facing upward (pump and tank port underneath).

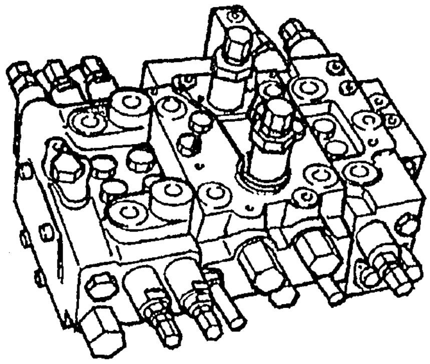


Fig. 25

3.3.1 DISASSEMBLING THE TRAVEL SPOOL

1) Remove socket bolt (46) and cover (44).

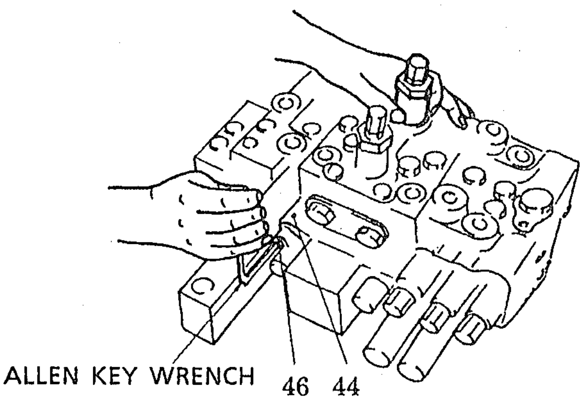

ALLEN KEY WRENCH
46
44

Fig. 26

2) Remove the spool as a spool assembly with spring (40), spring seat (41), socket bolt (43), seal retainer (39), O ring (37) and dust wiper (38).

☞ When taking out the spool ass'y from casing (2), do it slowly so that casing (2) may not be scored.

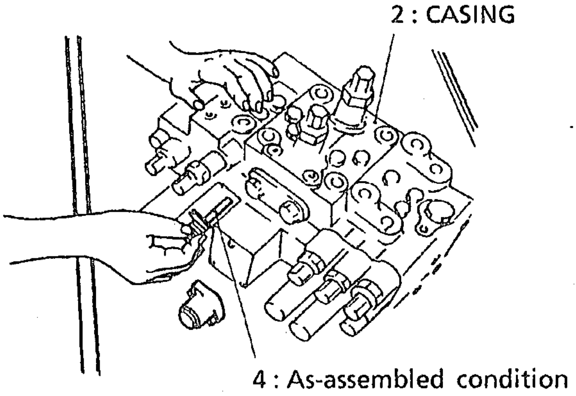

2 : CASING
4 : As-assembled condition

Fig. 27

3) Remove seal retainer (39), O ring (37) and dust wiper (38) on the front by removing socket bolt (45).

4) Clamp the I-shaped part of travel spool (4) in a vice fitted with a cushion ; loosen and remove socket bolt (43), and disassemble spring (40), spring seat (41), spacer (42), seal retainer (39), O ring (37) and dust wiper (38).

☞ As spring (40) has a long free length, it may pop out when socket bolt (43) is removed; hold spring seat (41) by hand.

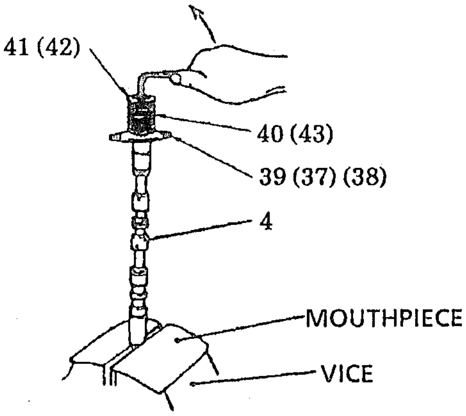

41 (42)
40 (43)
39 (37) (38)
4
MOUTHPIECE
VICE

Fig. 28

3.3.2 DISASSEMBLING THE BOOM SPOOL

1) Loosen socket bolt (34), remove cover (29), and dismantle spool (boom) (6), spring seat (25,26), spring (108,109) and spool end (23) in an assembled condition, from casing B (102).

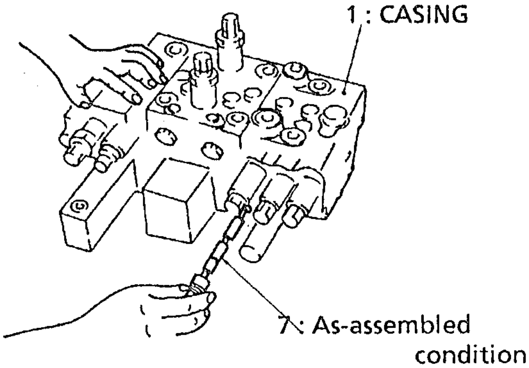

1 : CASING
7 : As-assembled condition

Fig. 29

☞ ● When drawing out the spool ass'y from casing (1), use care so as not to score the casing (1).

● Identify it properly to prevent it from being mistaken during assembly.

2) Clamp the double-sided end of the spool assembly in a vice ; loosen and remove spool end (23), and disassemble spring seats (25,26) and springs (108,109) from boom spool (6).

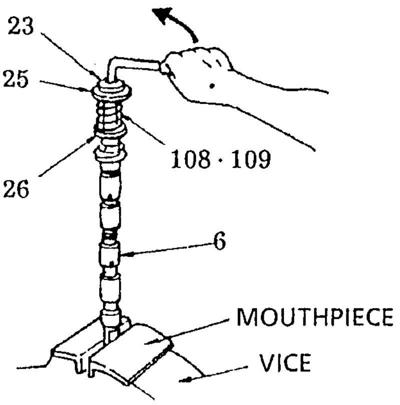


Fig. 30

3.3.3 DISASSEMBLING THE BUCKET SPOOL

1) Loosen socket bolts (34) the same way as the boom spool and remove cover (29), and then draw out the spool ass'y consisting of spool (bucket) (5), spring seat (25,26), springs (108, 109) and spool end (23), from casing (1).

☞ ● When drawing out the spool ass'y from casing (1), use care so as not to score the casing (1).

● The spool has a different shape than other spools and also has an orientation to which it must be installed. Therefore, identify it properly to prevent it from being mistaken during assembly.

2) Clamp the double-sided end of the spool assembly in a vice ; loosen and remove spool end (23), and disassemble spring seats (25,26) and spring (108, 109) from boom spool (5).

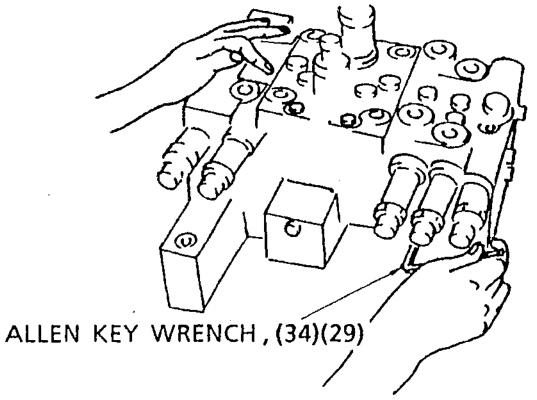


Fig. 31

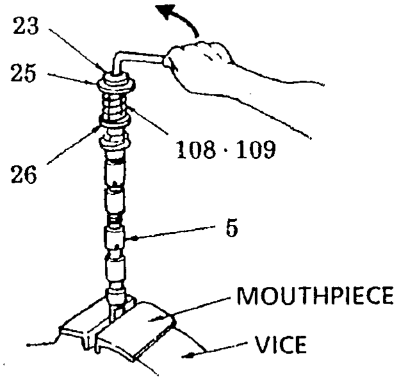


Fig. 32

3.3.4 DISASSEMBLY OF ARM SPOOL

1) Loosen socket bolt (36) and remove return spring casing (31) ; then pull the spool assembly with arm spool assembly (7), spring seats (116,117), springs (104,105), spool end (24) and cap (106) from casing (3).

☞ ● When drawing out the spool ass'y from casing (3), use care so as not to score casing (3).

● The spool has a different shape than other spools and also has an orientation to which it must be installed. Therefore, identify it properly to prevent it from being mistaken during assembly.

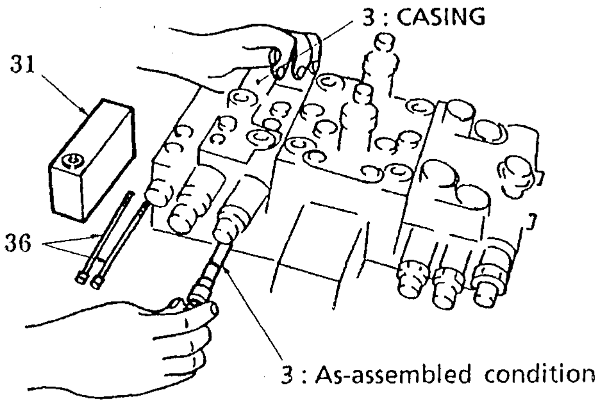


Fig. 33

2) Clamp the double-sided end of the spool assembly in a vice (hold at the spring side, unlike for the boom and bucket spools) ;apply a spanner〔 nominal dia.:10mm (0.39″) 〕to the double-sided part at the center of the spool; loosen and remove it; then disassemble spring seats (116,117), spring (104,105) and cap (106).

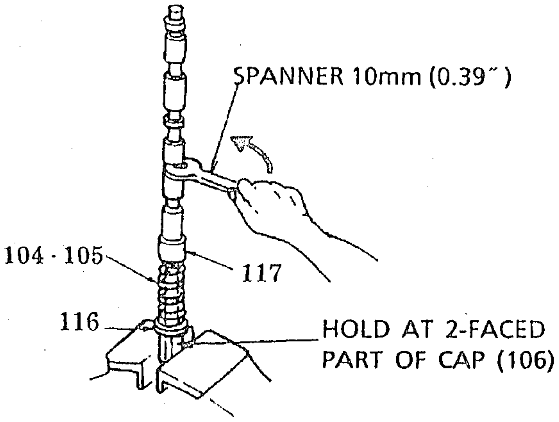


Fig. 34

3) Unless otherwise necessary, do not disassemble spool (arm)(7) any further.
In case further disassembly is required, do it according to the following procedure:

   a) Clamp the center of arm spool (7) in a vice fitted with a cushion ; apply a box wrench〔 nominal dia. : 13mm (0.51″) 〕to the double-sided part of spool end (24), then loosen and remove it.

☞ Use care so as not to deform arm spool (7) by overtightening in a vise.

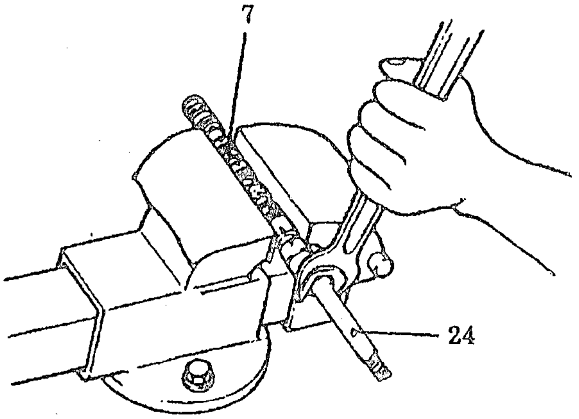
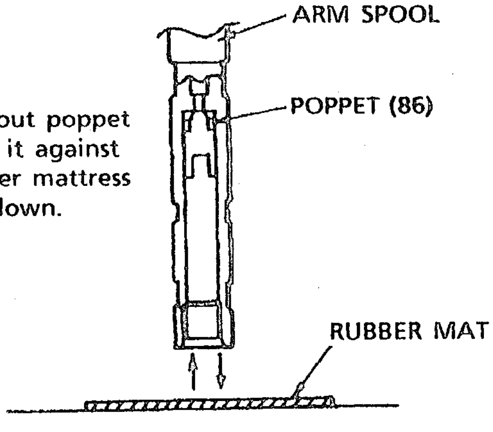


Fig. 35

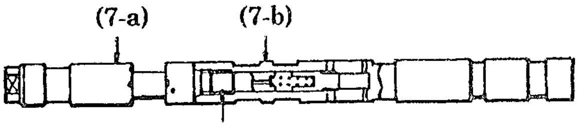
   b) Take out poppet (86) and spring (87) built into the arm spool.



To take out poppet (86), put it against the rubber mattress up and down.

Fig. 36

☞ Arm spools (7-a) and (7-b) cannot be disassembled ; never try to loosen their screws.
Therefore, valve (7-c) and spring (7-d) cannot be disassembled.



Never loosen this spring. (If loosened, spool function will be damaged.)

Fig. 37

3.3.5 DISASSEMBLY OF STRAIGHT TRAVEL SPOOL, BY-PASS CUT SPOOL AND CONFLUENCE SPOOL

1) To disassemble the straight travel spool, loosen and remove cap (52), then pull out spring (85), spring seat (27) and spool (8).

☞ ● When drawing out the spool ass'y from casing (2), use care so as not to score casing (2).

● The spool has a different shape than other spools and also has an orientation to which it must be installed. Therefore, identify it properly to prevent it from being mistaken during assembly.

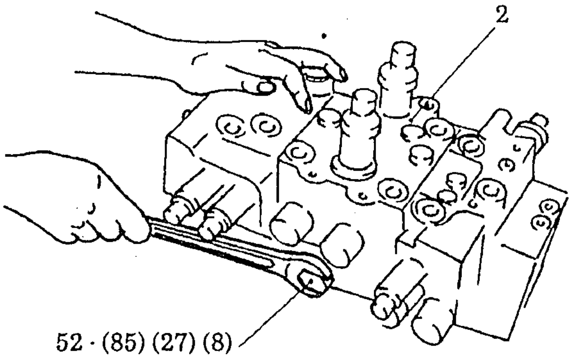


Fig. 38

2) Filter (59) is built into spool(8). To disassemble, pass a suitable pin into the hole [Ø3.5 (0.14")] in the left end of the spool ; loosen and remove retainer (60) by using this as lock pin; then filter (59) may be taken out.

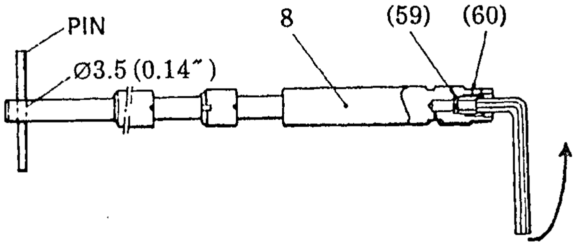


Fig. 39

3) To disassemble the by-pass cut spool, loosen and remove cap (52) and pull out spring (114) spring seat (27) and spool (9). (At 2 positions)

☞ ● When drawing out the spool ass'y from casing (1,3), use care so as not to score casing.

● The spool has a different shape than other spools and also has an orientation to which it must be installed. Therefore, identify it properly to prevent it from being mistaken during assembly.

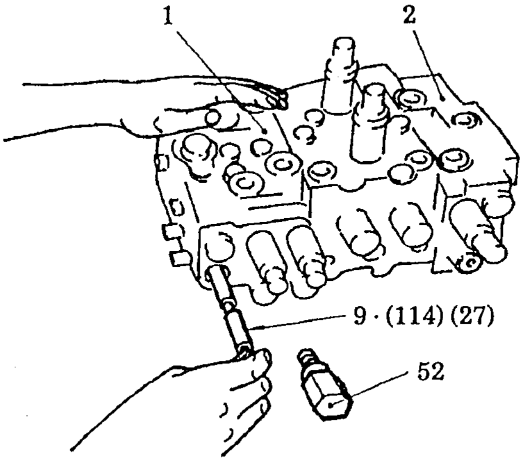


Fig. 40

4) Filter (59) is built into spool (9).

To disassemble, pass a suitable pin into the hole [Ø3.5 (0.14")] in the left end of the spool; loosen and remove retainer (60) by using this as lock pin ; then filter (59) may be taken out.

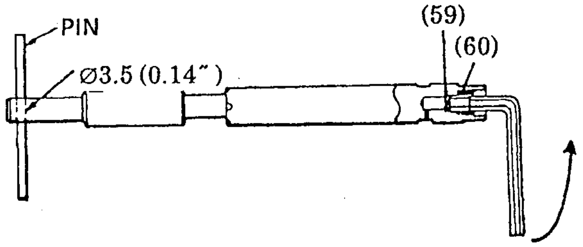


Fig. 41

5) To disassemble the confluence spool loosen and remove cap (52) and pull out spring (28), spring seat (27) and spools (10,11).

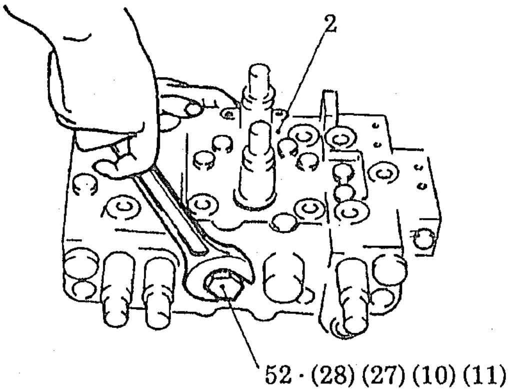


Fig. 42

☞ ● When drawing out the spool ass'y from casing (2), use care so as not to score casing (2).
● The spool has a different shape than other spools and also has an orientation to which it must be installed. Therefore, identify it properly to prevent it from being mistaken during assembly.
Pay special attention as the arm confluence spool and boom confluence spool are shaped differently shaped.

3.3.6 DISASSEMBLY OF LOAD CHECK VALVE

1) Loosen and remove plug (48) or (49); remove poppet (47) and spring (50).

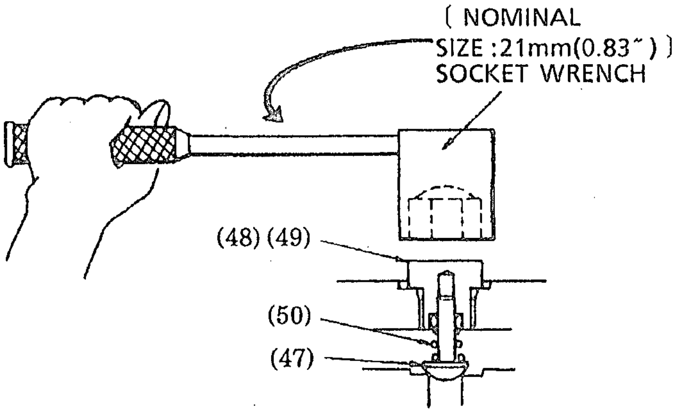


Fig. 43

☞ Remove all load check valves at 9 positions.
Plug (49) can be found at only 2 positions on top of the travel spool.
(Pay attention not to confuse them at the time of assembly.)

3.3.7 DISASSEMBLY OF SHUTTLE VALVE

There are 4 kinds of shuttle valve plugs.
Loosen and remove all shuttle valve plugs (66,67,68) (119) and take out ball (64) and other inner components.
As all parts are different, attach an identifying tag to avoid confusion at the time of assembly.

3.3.8 REMOVAL OF RELIEF VALVE

Remove main relief valve (71-A) and port relief valve (72-B) from the casing.

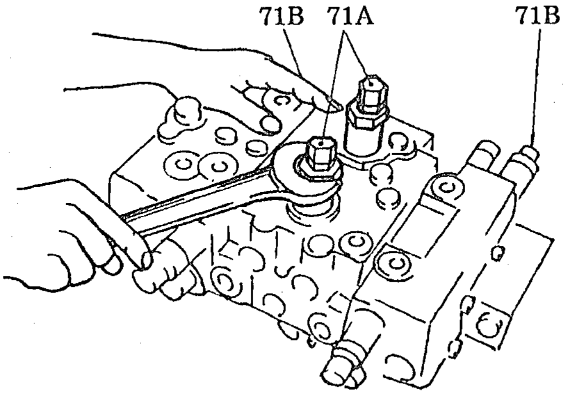


Fig. 44

☞ ● The travel relief valve in 2 locations have higher set pressures than those in 2 other locations; attach an identifying tag to be able to tell them apart.
● Similar identification measures are necessary for the port relief valve.

3.3.9 DISASSEMBLY OF ARM CONFLUENCE SEQUENCE VALVE

1) Remove the arm confluence sequence valve as an assembly from casing (3).
   It can be done easily by loosening socket bolt (32).
2) To disassemble sequence valve spool (89), loosen and remove piston casing (96) ; then take out piston (95), spring (90), spring seat (91) and sequence valve spool (89) in that order.
3) To disassemble pilot piston (92), loosen and remove plug (99) on the other side ; then it can be taken out along with the piston guide.

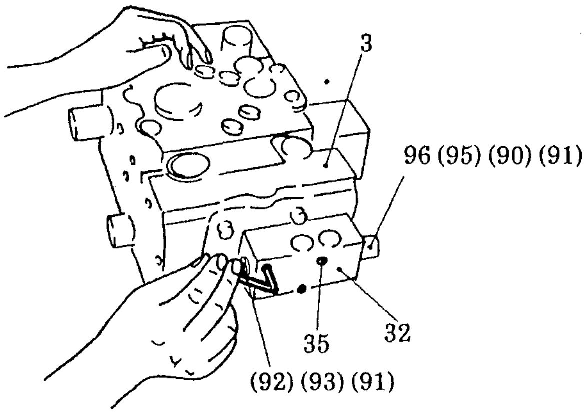


Fig. 45

3.3.10 DISASSEMBLY OF ANTI-CAVITATION VALVE

The anti−cavitation valve is screwed into the bottom of the boom operating part.

1) To disassemble, apply an socket wrench [nominal dia.: 26mm (1.0″)] to the hex part of cap (80) ; loosen and remove.
2) Socket (74) and valve (73) can be taken out as a cartridge.

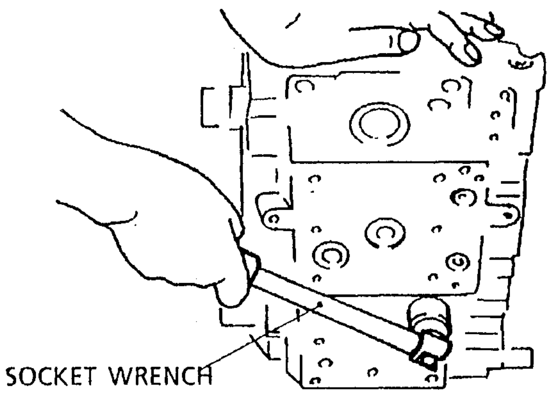


Fig. 46

3.3.11 DISASSEMBLY OF CASING

The casing is made up of parts A(1), and C(3), which are joined together with socket bolts (16) and (17).

1) Do not remove the socket bolts (16) and (17) unless otherwise necessary, for specific reasons.

☞ Socket bolts are tightened to a torque of 4.5kgf·m (33 ft·lbs) and spool holes are fine−finished ; if this torque is not observed at the time of assembly, the spool hole may be warped.

2) Those plugs not mentioned in the above−mentioned disassembly procedure are for extra holes and for keeping the casting clean. Do not disassemble them unless otherwise necessary for specific reasons.

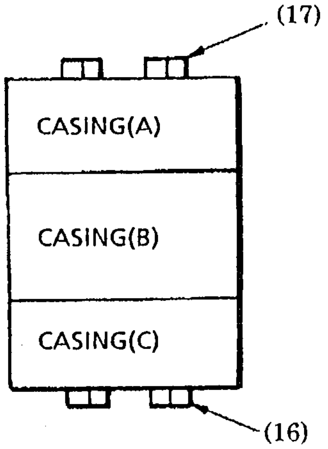


Fig. 47

3.3.12 DISASSEMBLY OF MAIN RELIEF VALVE

The numbers in parentheses after part names in the explanation correspond to those in the construction drawing (Fig. 3).

(1) If the main relief valve is faulty, replace the entire assembly because socket (1) and plunger (2) are select-fit, pressure setting after assembly is difficult and special tools are needed for disassembly.

(2) For your reference, the disassembly procedures using those special tools are listed below.

1) Separate socket (1) and body (4).

2) Seat (8) and other inner parts (15)(16)(17)(18)(3)(2) can be taken out from inside of socket (1).

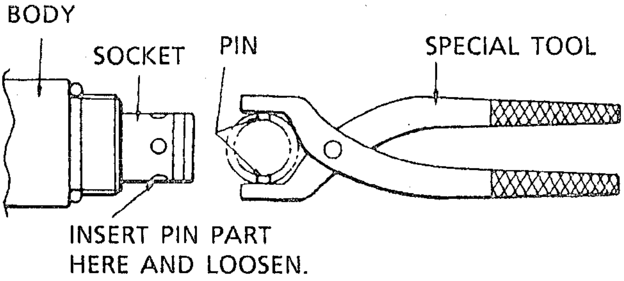


Fig. 48

3.3.13 DISASSEMBLY OF PORT RELIEF VALVE

The numbers in parentheses after part names in the explanation correspond to those in the construction drawing (Fig. 4)

(1) Replace as an assembly like the main valve.

(2) Disassemble as follows:

1) Loosen the screw joining body (8) and body (4).

2) Socket (1) spring (3) and plunger (2) can be taken out.

3) To disassemble the poppet, loosen and remove lock nut (14) and nut (12); take out spring (10) and poppet (9).

Pull out poppet (9) by gripping the shaft with needle−nose pliers or the like.

3.3.14 INSPECTION AFTER DISASSEMBLY

Wash all disassembled parts with meneral oil thoroughly, and after drying them with jet air, place parts on a clean paper or a cloth for inspection.

(1) Control Valve

1) Inspect that all surfaces of each part is free from burr, scratch, notch or other defect.

2) Confirm that the sealing grooves on the casing and block are smooth and free from dirt, dimple and rust.

3) Thoroughly inspect the check valve seat of the casing for dents and flaws.

4) Confirm that the sealing surface and the sliding surface of the manual spool are free from scratch and blow mark, and if faults are small, eliminate them, using an oilstone or a cloth impregnated with lapping medium.

5) Confirm that all sliding and mating parts move lightly by hand and that all grooves and passages are free from foreign matter.
6) Replace springs with new ones if they are broken or deformed.
7) If a relief valve is faulty, correct it according to the disassembly and assembly procedures for relief valves.
8) Replace all seals and O rings with new ones.

(2) Relief Valve

1) Confirm that the seat surface at the top end of each poppet and seat is free from fault showing even contact.
2) Confirm that the plunger and socket slide smoothly when moved by hand.
3) Confirm that there is no scratch marks on the outer circumference of the main poppet and the inner surface of the seat.
4) Confirm that springs are not broken, deformed nor worn.
5) Confirm that no foreign matter is clogged in the orifices of the main poppet and the seat.
6) Replace all O rings with new ones.
7) If you find minimal faults after the above inspections,eliminate them by lapping.
8) When abnormal parts are found, replace the relief valve ass'y.

3.4 ASSEMBLY

(1) This paragraph provides instructions only. For illustrations, refer to the paragraph under disassembly.

(2) The figures in parentheses after part names in the following instructions correspond to those in the construction drawing.

(3) Reminds when Fitting Seals

1) Handle seals with care so that they may not be scored.
2) Apply grease or hydraulic oil to seals and seal fitting areas for sufficient lubrication.
3) Avoid stretching seals to an extent that may deform them permanently.
4) When fitting O rings, do not roll them into the grooves. Twisted O rings are hard to return to normal after setting, causing oil leaks.
5) Tighten mounting bolts by means of a torque wrench to tightening torques indicated in "Maintenance Standards ".

3.4.1 ASSEMBLING THE CASING

Fig. O ring (12,14,15) to O ring groove of casing A (1) and casing C (3) and tighten socket bolts (16,17) to a specified torque.

☞ Confirm that mating surfaces are free from dirt and that O rings are set in place in the O ring grooves.

3.4.2 ASSEMBLING RELIEF VALVES

1) Tighten main relief valve (71-A)(71-B), and port relief valve (72) to each casing to specified torques.

☞ ● The travel relief valves in 2 locations have components exactly the same as those in 2 other locations. But as the set pressure is different, pay attention when assembling by checking identification tags attached at the time of disassembly.
● Some port relief valves have different pressure settings, check ID tags attached at the time of disassembly in order to install in the original place.
● For assembling relief valves, refer to a separate assembly procedure.

3.4.3 ASSEMBLY OF ARM CONFLUENCE SEQUENCE VALVE

1) Assemble by reversing the procedure for disassembly.
2) Fit assembly to casing C (3) by screwing in socket bolt (35).

☞ ● Confirm that mating surfaces are free of dirt and that the O ring is securely fit into the O ring groove.
● Tighten socket bolt (35) to specified torque.

3) For pressure adjustment, see the separately available "Maintenance Standards and Test Procedures".
Leave adjusting screw (100) free.

3.4.4 ASSEMBLY OF SHUTTLE VALVE

1) The shuttle valves are assembled at 5 locations and there are 3 kinds of shuttle valves.

☞ ◎ The shuttle valve downstream of the boom confluence valve is specially shaped; be sure to put all its parts in 〔 in particular ball (112) and spring (70) 〕.

◎ Be careful not to lose the balls (64) (112). 〔 Put a little grease on the seat of the shuttle valve, stick the ball on top of it, and screw it in. 〕

3.4.5 ASSEMBLY OF CHECK VALVE

1) Assemble poppet (47) and spring (50) ; put O ring (51) into plug (48) or (49), and tighten to the specified torque.

☞ ◎ Plug (49) is used in only 2 places on the top of the travel spool ; be sure to install correctly.

◎ To screw in plugs (48,49), manually screw in until the shaft of poppet (47) hits the guide hole of the plug, and then tighten with a socket wrench 〔 nominal dia.: 21mm (0.83″) 〕 to the specified torque.

3.4.6 ASSEMBLY OF STRAIGHT TRAVEL SPOOL, BY-PASS CUT SPOOL AND CONFLUENCE SPOOL

1) Fit all spools (8)(9)(10)(11) into the specified position, previous marked with a tag.
2) Fit spring seat(27) to the guide of the spool. (Don't leave any parts behind.)
3) Fit spring and other parts into cap (52), then screw cap (52) into the main body.

3.4.7 ASSEMBLY OF BUCKET SPOOL

1) Clamp the double-sided part of bucket spool (5) in a vice ; set spring seat (26), springs (108) (109) and spring seat (25) ; tighten spool end (23) to the specified torque.

☞ ◎ Before tightening spool end (23) apply Three Bond 1360K (Loctite #242).

◎ Slowly tighten spool end (23), checking that the double spring is securely set to spring seats (25)(26).

2) Assemble the spool assembly from 1) above into casing A (1).

☞ To assemble the spool assembly into casing A (1), set it straight along the shaft center, and slowly push it in. (Never force it in.)

3.4.8 ASSEMBLY OF BOOM SPOOL

1) Clamp the double-sided part of boom spool (5) in a vice ; set spring seat (26), springs (108)(109) and spring seat (25) ; tighten spool end (23) to the specified torque.

☞ ◎ Before tightening spool end (23) apply Three Bond 1360K (or equivalent).

◎ Slowly tighten spool end (23), checking that the double spring is securely set to spring seats (25)(26).

2) Assemble the spool assembly from 1) above into casing A (1).

☞ ○ To assemble the spool assembly into casing A (1), set it straight the shaft center, and slowly push it in. (Never force it in.)

3.4.9 ASSEMBLY OF ARM SPOOL

1) Assemble poppet (86) and spring (87) into the spool and tighten spool end (24) to the specified torque.

☞ Before tightening spool end (23) apply Three Bond 1360K (or equivalent).

2) Clamp the center of arm spool (7) in a vice ; set spring seat (117), springs (104)(105) and spring seat (116) ; tighten cap (106) to the specified torque.

☞ ○ Take care not to damage or deform the surface of arm spool (7) by over-tightening in the vice.

○ Before tightening cap (106) apply Three Bond 1360K (or equivalent).

○ Spring seats (117) (116) and springs (104)(105) are exclusive parts for the arm ; do not get them confused with parts for the bucket or boom. 〔 In arm spring seats (117)(116), a groove is worked onto the outer circumference for identification. 〕

○ Tighten cap (106) while checking that the double spring is securely set to spring seats (117)(116).

3) Assemble spool assembly from 1) and 2) above into casing C (3).

☞ To assembly the spool assembly into casing C (3), set it straight along the shaft center, and slowly push it in. (Never force it in.)

3.4.10 ASSEMBLY OF TRAVEL SPOOL

1) Clamp the I-shaped part (pin joint) of travel spool (4) in a vice ; assemble O ring (37), dust wiper (38),seal plate (39), spring (40), sleeve (42), spring seat (41) and socket bolt (43) to the opposite end ; tighten socket bolt (43) to the specified torque.

☞ ● As spring (40) has a long free length, hold it down by hand when tightening socket bolt (43).
● Before tightening socket bolt (43) apply Three bond (or equivalent).
● When the threads of socket of socket bolt (43) begin engaging with those of travel spool (4), slowly tighten by checking that spacer (43) and spring seat (41) are positioned at the shaft center.

2) Assemble spool assembly from 1) above into casing B(2).

☞ To assemble the spool assembly into casing B (2), set it straight along the shaft center, and slowly push it in. (Never force it in.)

3) Set cap (44) on the spring side and tighten socket bolt (46) to the specified torque.
4) For the pin joint part on the other side, set O ring (37) and dust wiper (38) into the casing seal groove ; press them with seal plate (39), and tighten socket bolt (45) to the specified torque.

3.4.11 ASSEMBLY OF COVERS

1) Set cover (29) to the spring side of the bucket/ boom spool, and tighten socket bolt (34) to the specified torque.
2) Set return spring casing (31) to the spring side of the arm spool, and tighten socket bolt (36) to the specified torque.
3) Set cover (30) on the side opposite the spring of the bucket, boom and arm spools, and tighten socket bolt (34) to the specified torque.

☞ Be sure to put on all O rings (33).

3.4.12 ASSEMBLY OF MAIN RELIEF VALVE AND PORT RELIEF VALVE

1) Assemble by reversing the procedure for disassembly.
2) For pressure adjustment, see the separate manual "Maintenance Standards and Test Procedures".
Leave adjusting screw provisionally assembled.

4. MAINTENANCE STANDARDS

4.1 INSPECTION OF PARTS

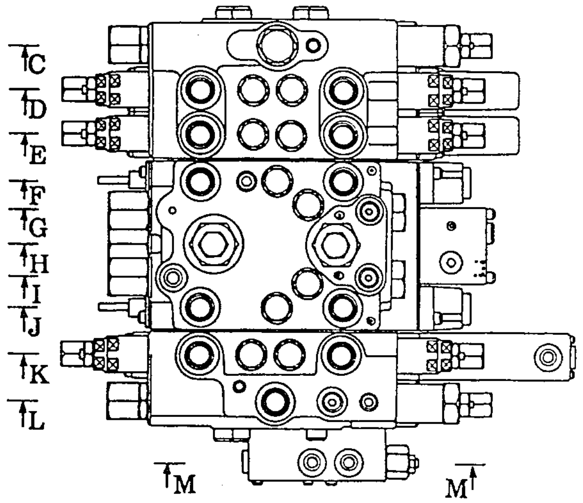
Part Name	Inspection Item	Acceptance Criterion and Remedy
Casing	1) Presence of scratch, rust and corrosion.	1) Replace parts that are scored on the following areas: ○ Sliding surface between casing hole and spool, particularly the land area subject to hold pressure. ○ Seal pockets where spools enter. ○ Sealing areas of ports in contact with O rings. ○ Sealing areas of main, travel and port relief valves. ○ Other damages deemed to undermine normal functions.
Spool	1) Presence of scratch, galling, rust and corrosion. 2) Areas on both ends sealed by O rings. 3) Stroke the spool inserted in a casing hole, while rotating it.	1) Replace spool that have faults of extents that can be scratched by your nails (on the outer circumference, particularly on area in contact with seals). 2) Replace spool that have scoring on the sliding surface. 3) Correct or replace such a spools that may scratch O ring or that do not move smoothly.
Poppet	1) Poppet and spring are damaged. 2) Insert poppet into casing and let it operate.	1) Correct or replace poppet that provide incomplete sealing. 2) It is normal if it moves smoothly without being caught.
Spring and related parts	1) Spring, spring seat, plugs or covers is rusted, corroded, deformed or broken.	1) Replace those showing excessive fault.
Spool seal and related areas	1) Oil leakage to outside. 2) Seal plate is rusted, corroded or deformed.	1) Correct or replace. 2) Correct or replace.
Main relief valve. Port relief valve.	1) Outer surface is rusted or damaged. 2) Contact surface of valve seat 3) Contact surface of poppet 4) That spring is not faulty. 5) O rings, backup rings and seals	1) Replace. 2) Replace one that is damaged. 3) Replace one that is damaged. 4) Replace. 5) Replace all as a rule.

4.2 PRESSURE ADJUSTMENT OF RELIEF VALVES

For the pressure adjustment of relief valves, refer to the separate "Service Standard and Test procedure".

4.3TIGHTENING TORQUE

(1) Control valve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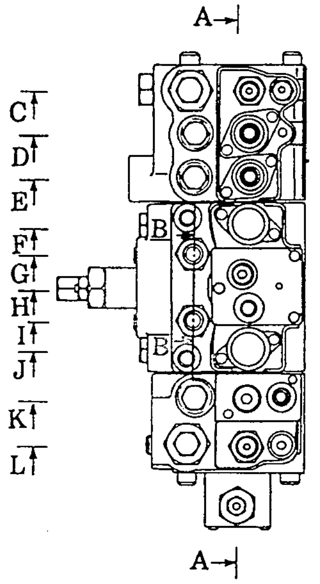
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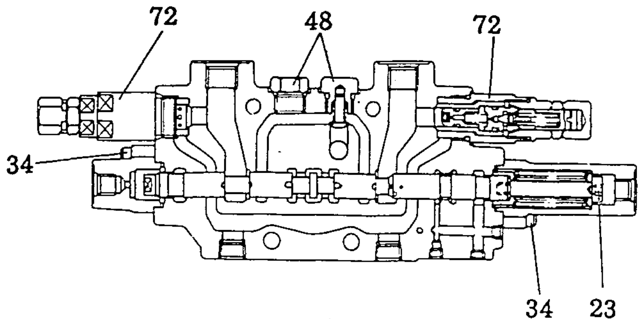
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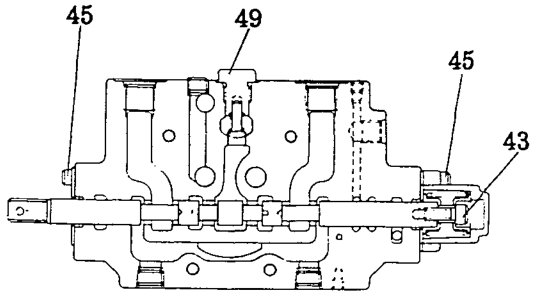
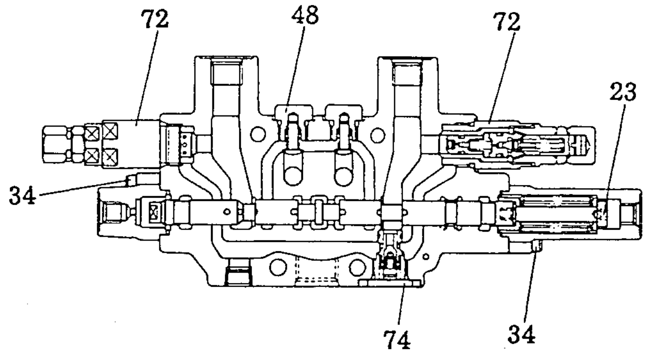


SECTION F－F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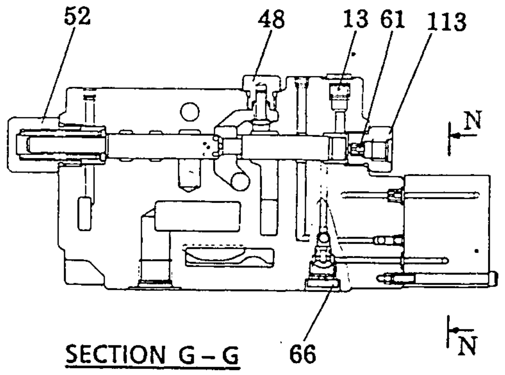
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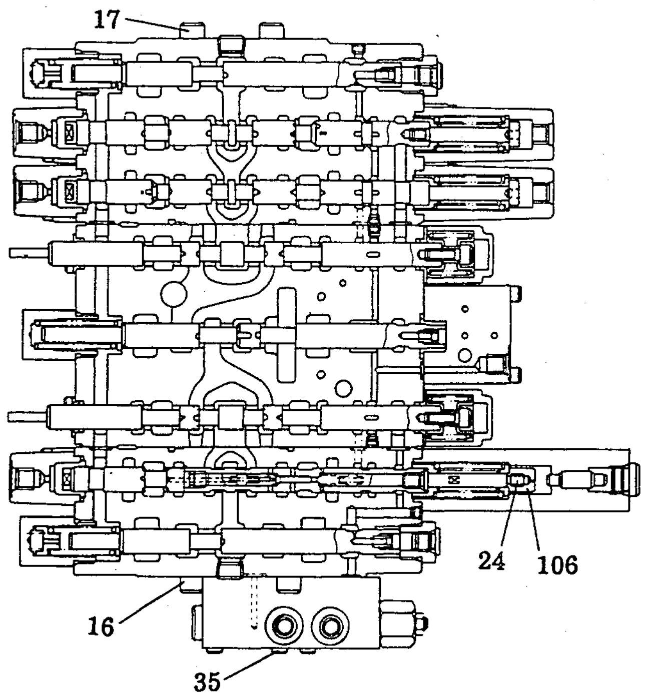
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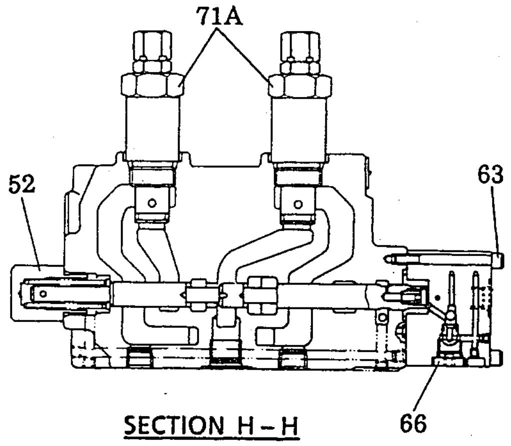

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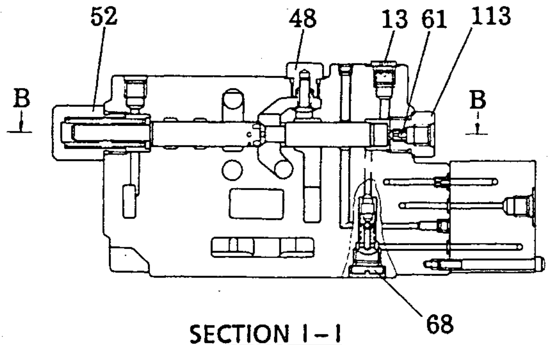
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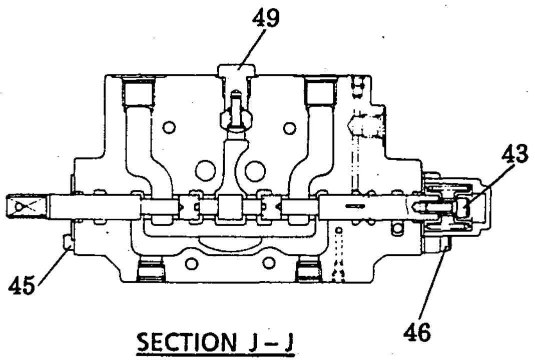

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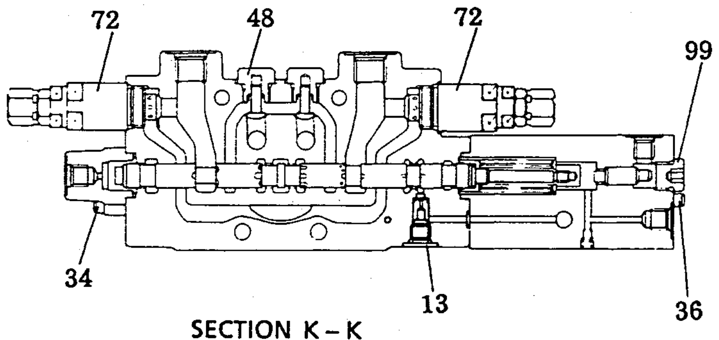
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13
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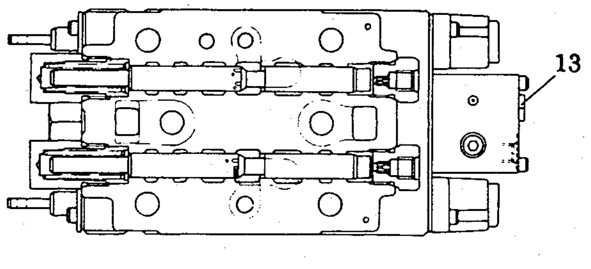

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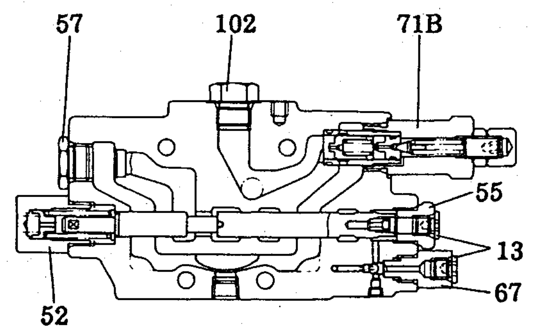
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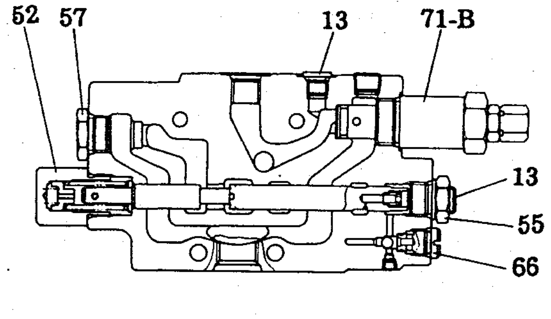
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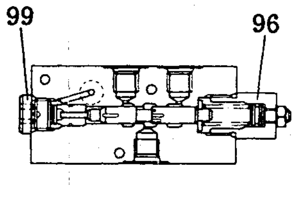

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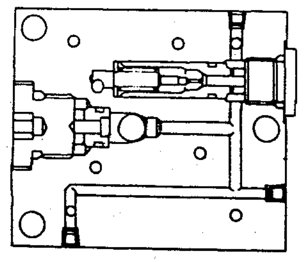

SECTION N－N

Table 5　　Unit : kgf · m(ft · lbs)

Symbol	Name	Tightening Torque	Remarks
13	Plug	2.5~3 (18 ~22)	PF1/4
16	Socket bolt	$4.5^{+0.2}_{0}$ (33^{+1}_{0})	M12
17	Socket bolt	$4.5^{+0.2}_{0}$ (33^{+1}_{0})	M12
23	Spool end	2.0~2.2 (14~16)	M8 ※
24	Spool end	2.5~2.7 (18~20)	M10 ※
34	Socket bolt	1.2~1.4 (9~10)	M6
36	Socket bolt	1.2~1.4 (8~10)	M6
43	Socket bolt	2.0~2.2 (14~16)	M8 ※
45	Socket bolt	1.2~1.4 (9~10)	M6
46	Socket bolt	1.2~1.4 (9~10)	M6
48	Plug (check valve retainer)	5~7 (36~51)	PF3/8
49	Plug (check valve retainer)	5~7 (36~51)	PF3/8
52	Cap	6~8 (43~58)	M27×1.5
55	Bush	6~8 (43~58)	M27×1.5
57	Plug	6~8 (43~58)	M24×1.5
61	Destriction	0.5~0.8 (4~6)	M6 ※
63	Socket bolt	1.2~1.4 (9~10)	M6
66	Shuttle valve plug	2.5~3 (18~22)	PF3/8
67	Shuttle valve plug	2.5~3 (18~22)	PF3/8
68	Shuttle valve plug	2.5~3 (18~22)	PF3/8
71	Relief valve assembly	6.5~7 (47~51)	M30×1.5
72	Port relief valve assembly	6.5~7 (47~51)	M27×1.5
74	Cap	6~8 (43~58)	M22×1.5
96	Piston case	6~8 (43~58)	M22×1.5
99	Plug	5~7 (36~51)	M18×1.5
102	Plug	6~8 (43~58)	PF1/2
106	Cap	2.0~2.2 (14~16)	M8 ※
113	Bush	6~8 (43~58)	M22×1.5

☞ ※ : Apply Three Bond 1360K (Loctite #242)

5. TROUBLESHOOTING

1) When you find a malfunction or a fault, investigate whether or not it comes from the control valve,pump body, No3 pump or hydraulic circuits. For this purpose it is necessary to measure pilot pressure. pump discahrge pressure and load pressure. If any part of the control valve is disassembled and inspected, do it according to the above mentioned disassembly and assembly procedures.
2) Dust is extremely harmful to hydraulic components.
   Use care so asnot to allow dust from intruding inside. Take dustproofing measures in case any part of the control valve is to be disassembled.
3) Handle sliding parts with care. Correct even minor faults that have been produced, using an oilstone or something.
4) Handle gasket surfaces of O rings so as not to score them as scoring will result in oil leakage.

5.1 CONTROL VALVE

Trouble	Cause	Remedy
1. Machine does not travel or travels at low speed (force not sufficient) or responds slowly.	1) Travel relief valve malfunctions. ○Dirt is included between main poppet and seat. ○Dirt included between poppet and seat. ○Main poppet is stuck. ○Spring is broken or deformed. ○Restriction in main poppet is clogged. ○Loosen adjust screw.	1) Measure pressure of travel relief valve. ○Replace assembly when fault is large. ○Same as above ○Correct stuck part with an oilstone. ○Replace spring. ○Eliminate dirt. ○Readjust and tighten locknut to a specified torque.
	2) Orifice in pilot line is clogged.	2) Eliminate dirt.
2. Machine makes a crooked travel when travel and attachment motions are exccuted at the same time.	1) Travel preferential changeover valve malfunctions. ○Spool is stuck. ○Spring is broken or fatigued. ○Clearance between casing (B) and spool is excessive.	1) Measurement of pilot pressure ○Correct stuck part with an oilstone. ○Replace spring. ○Replace spool.
	2) Shuttle valve malfunctions. ○Air intruded in pilot line. ○Dirt included between bowl and seat. ○Fault on seat surface	2) Measurement of pilot pressure ○Air bleeds ○Disassemble and clean. ○Correct with an oilstone or replace seat if fault is large.
	3) RH and LH neutral cut valves malfunction. ○Spool is stuck. ○Spring is broken or fatigued. ○Clearence between casing (A or C) and spools is excessive.	3) Measurement of pilot pressure ○Correct stuck part with an oilstone. ○Replace spring. ○Replace spool.
	4) Logic valve malfunctions ○Dirt clogged between poppet and seat surface. ○Fault produced on poppet seat surface.	○Eliminate dirt. ○Correct with an oilstone. If fault is large, replace seat and poppet.

Trouble	Cause	Remedy
	○Spring is broken or fatigued.	○Replace spring.
	5) Travel relief valve malfunctions. (See 1.1 above.)	5) Measure pressure on travel relief valve. (See 1.1 above.)
3. Cylinder falls much by its weight when spool is neutral.	1) Clearance between casing and spool is large.	1) Replace spool.
	2) Spool is not returned to perfect neutral. ○Dirt is included between casing and spool, or casing and spool are stuck together. ○Spring is broken or fatigued. ○Dirt is clogged in pilot line.	2) Measure secondary pilot pressure. ○Disassemble, clean and correct stuck part with oil stone. ○Replace spring. ○Remove dirt.
	3) Main relief valve malfunctions. (See 1.1 above.)	3) Measure pressure on main relief valve. (See 1.1 above.)
	4) Port relief valve malfunctions. (See 1.1 above.)	4) Measure pressure on main relief valve. (See 1.1 above.)
	5) Anti-cavitation check valve malfunctions. ○Dirt included between poppet and casing. ○Spring is broken or fatigued.	5) ○Disassemble and clean. ○Replace spring.
4. When lever is turned to Cylinder Hoisting, it falls at the beginning.	1) Load check valve malfunctions. ○Dirt included between poppet and casing. ○Poppet is stuck. ○Spring is broken or fatigued.	1) ○Disassemble and clean. or replace casing when fault is large. ○Correct stuck part with an oil stone. ○Replace spring.
5. Only bucket, boom and arm do not work. Action is slow (force insufficient) or response is slow.	1) Main spool malfunctions ○Clearance between casing (A or C) and spool is excessive. ○Dirt is included between casing and spool. ○Spool is stuck. ○Return spring is broken or fatigued. ○Dirt is clogged in pilot line.	1) Measure secondary pilot pressure. ○Replace spool or casing. ○Disassemble and clean. ○Correct stuck part with an oil stone. ○Replace spring. ○Remove dirt.
	2) Main relief valve malfunctions. (See 1.1 above.)	2) Measure pressure on main relief valve. (See 1.1 above.)
	3) Port relief valve malfunctions. (See 1.1 above.)	3) Measure pressure on port relief valve. (See 1.1 above.)
	4) pilot valve malfunctions. See a separate Manual for Control system.	4) See a separate Manual for Control System.

Trouble	Cause	Remedy
6. Swing preferential function does not work.	1) Logic valve malfunctions. (See 2 and 4 above.)	1) See 2 and 4 above.
	2) Orifice in pilot line is clogged.	2) Eliminate dirt.
7. Swing action does not work.	1) Neutral cut valve malfunctions. See 2 and 3 above.	1) See 2 and 3 above.
	2) Shuttle valve malfunctions. See 2.2 above.	2) See 2.2 above.
8. Boom and arm streams do not make a combined action.	1) Each confluent flow valve malfunctions. See 2 and 3 above.	1) Measure pilot pressure. See 2 and 3 above.
9. Negative control function does not work in neutral position, not providing a minimum flow,	1) Low pressure relief valve malfunctions. ○Dirt included between poppet and seat. ○Spring is broken or fatigued. ○Poppet restriction clogged. ○Filter is broken.	1) Measure pressure on low pressure relief valve. ○Disassemble and clean. if fault is large, replace assembly. ○Replace spring. ○Disassemble and clean. Eliminate dirt. ○Disassemble and clean. Replace filter.

5.2 RELIEF VALVES

Trouble	Cause	Remedy
1. Pressure does not rise at all.	Main poppet or pilot poppet in relief valve is stuck or remains open, or dirt is included in valve seat.	○Check for foreign matter included in mating parts of poppet. ○Check if parts slide freely. ○Clean all parts thoroughly.
2. Relief pressure is not steady.	Pilot poppet seat in relief valve is scored. Pilot piston is stuck with main poppet.	○Replace scored parts. ○Wash all parts thoroughly. ○Remove fault on surface.
3. Relief pressure is not correct.	1) Wear due to dirt.	1) Disassemble and clean.
	2) Locknut and adjust screw is slack.	2) Adjust pressure.
4. Oil leakage	1) Seat is scored. O ring is worn.	1) Replace scored or worn part. Check that all parts move smoothly.
	2) Parts are stuck due to dirt.	2) Check for scratch, notch or foreign mater inclusion before reassembly.

BooK code No. S514046 1E⑨

KOBELCO

SHOP MANUAL

RELIEF VALVE (PILOT)

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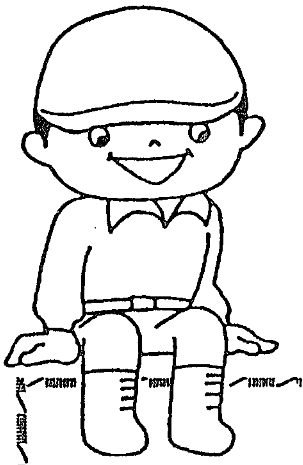
KOBE STEEL, LTD.



PREFACE

This pilot relief valve returns excess oil to the tank to protect gear pump and other hydraulic components in the system when the pilot pressure of oil discharged from gear pump exceeds the set value.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK200	YN-6501～	Spec.5			
SK200-LC	YQ-1101～	Spec.5			
SK220	LQ-2001～	Spec.5			
SK220-LC	LL-1801～	Spec.5			
SK120	LP-5201～	Spec.5			
SK100	YW-2801～	Spec.5			
SK60	LE-11001～	Spec.5			
SK50UR	YJ-00101～	Spec.5			

Revision	Date of Issue	Remarks
Fifth revision	March,1990	S5140461E⑧ K
Sixth revision	June, 1990	S5140461E⑨ K

1. SPECIFICATIONS

1.1 GENERAL VIEW

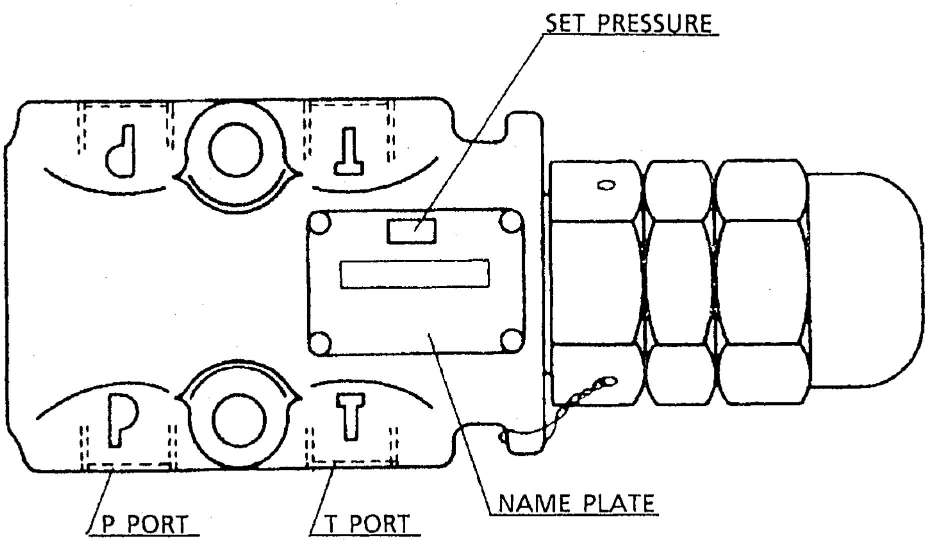


Fig. 1 Outside view of pilot relief valve

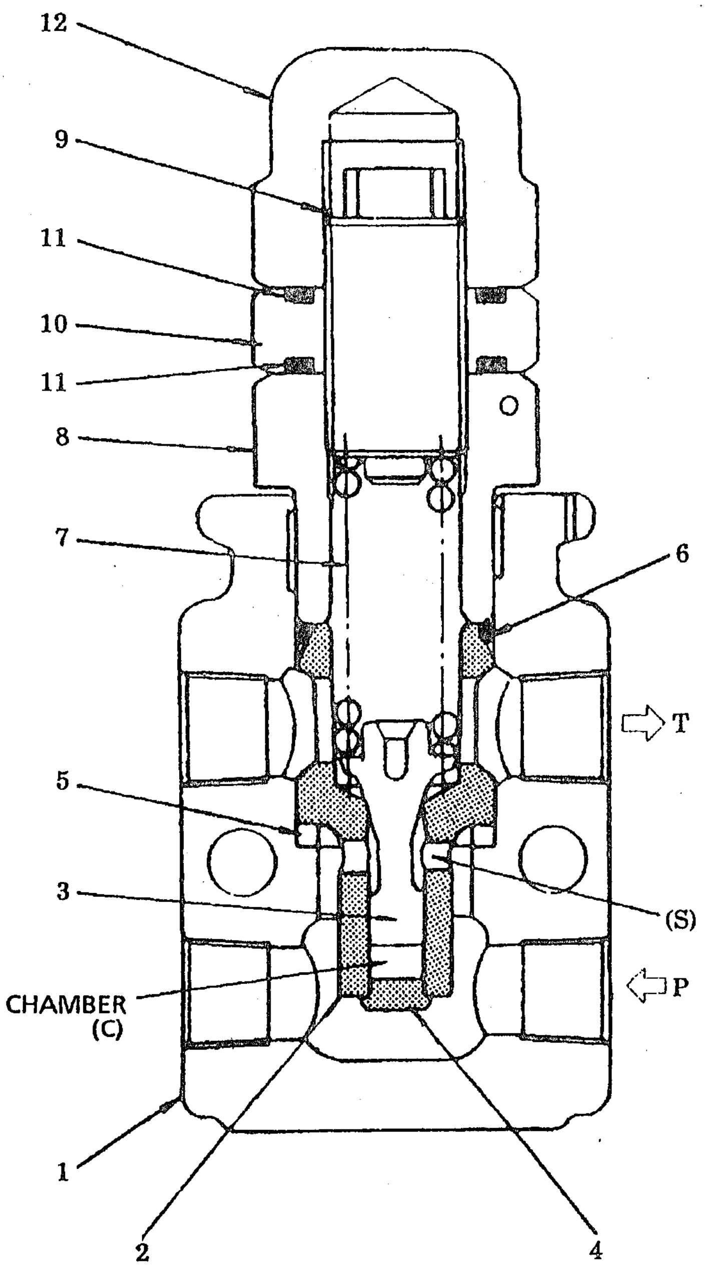
1.2 MAJOR DIMENSIONS

Table 1

Item	1	2	3	4	5	15	25
Model	VRD − 0300					VRD−03	VRD−06
P Port (Screw size)	PT3/8					JIS PF3/8 (O ring Port)	JIS PF3/4 (O ring Port)
T Port (Screw size)	PT3/8					JIS PF3/8 (O ring Port)	JIS PF3/4 (O ring Port)
Proof Pressure kgf/cm^2 (lbs/in^2)	140 (1991)						210 (2987)
Relief Set Pressure kgf/cm^2 (lbs/in^2)	10~100 (142~1422)						
Rated Flow ℓ/min (gal/min)	30 (7.9)						75 (19.8)
Relief Set Pressure kgf/cm^2 (lbs/in^2)	35 (498)	20 (285)	40 (569)	125 (1778)	43 (612)	50 (711)	50 (711)
Relief Set Flow ℓ/min (gal/min)	20 (285)	18 (256)	18 (256)	30 (427)	17 (242)	18 (256)	45 (640)
Weight kg (lbs)	1.8 (3.9)						3.4 (7.5)

2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION



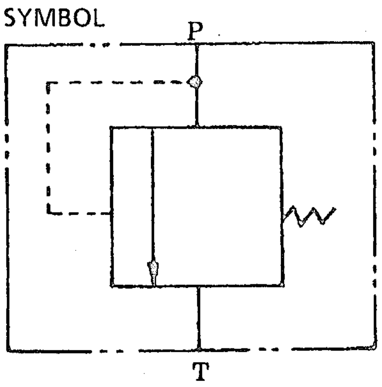


Table 2

NO.	NAME	Q'TY
1.	BODY	1
2.	HOUSING	1
3.	POPPET	1
4.	PLUG	1
5.	SEAT	1
6.	O RING	1
7.	SPRING	1
8.	SET SCREW	1
9.	ADJUSTING SCREW	1
10.	LOCK NUT	1
11.	O RING	2
12.	CAP	1

Fig. 2 Cross-sectional view of pilot relief valve

2.2 FUNCTION

Clearance is secured at the sliding surface between poppet (3) and housing (2) to allow free oil flow. Oil supplied from P port is conducted to chamber (C) through hole (S) of housing (2) and clearance at the sliding surface between the poppet and the housing. Spring force is strong enough that the poppet does not operate until the pressure in chamber (C) reaches at the relief valve set pressure. The moment the pressure in chamber (C) exceeds the cracking pressure, the hydraulic force becomes greater than the spring force, thereby detaching the poppet (3) from the seat of relief housing (2). Oil supplied from (P) port then flows from clearance between poppet and seat to tank port (T) through hole (S).

Displacement of poppet (3) is determined by flow rate and pressure. If the flow volume properly corresponds to the pressure, the pressure remains constant ; therefore the system pressure does not exceed the set pressure.

3. DISASSEMBLY AND ASSEMBLY

3.1 DISASSEMBLY

1) Grip body (1) on the vise, remove cap (12), lock nut screw (10) and set screw (8).
2) Remove spring (7) and O ring (6). From P port, remove poppet (3), together with housing (2), while pushing up plug (4).
3) Remove seat (5) from the body.

3.2 CLEANING AND INSPECTION

1) Clean all disassembled parts with clean washing oil.
2) Dry cleaned parts with compressed air, then place on clean paper for inspection.
3) Check faces of parts for damage.
4) If any, efface thoroughly with oilstone or lapping.
5) Check that the operating parts move smoothly.
6) Replace the spring if deformed or damaged.

3.3 ASSEMBLY

1) Insert seat (5) into body (1).
2) Install plug (4) and poppet (3) to housing (2), then insert into body.
3) Insert O ring (6) and spring (7) into body. Screw adjust screw (9) into set screw (8), then into body.
4) Screw lock nut (10) into adjusting screw (9), then attach O rings (11) to both-sides of lock nut.
5) Screw adjusting screw (9), with lock nut (10) attached, into plug (8).
6) Set pressure with adjusting screw (9), then tighten lock nut (10) to the specified torque.
7) Tighten cap (12) to the specified torque.

☞ • Tighten set screw (8), lock nut (10) and cap (12) to the tightening torque of 6±0.5kg·m (43±4 ft·lbs).

• Adjust pressure as follows: Confirm that the oil flows at specified flow rate. While observing the pressure gauge, tighten adjusting screw (9) until pressure is increased beyond set pressure. Then adjust pressure while loosening adjusting screw (9).

4. TROUBLESHOOTING

Table 3

Trouble	Cause	Remedy
1. External leakage of hydraulic oil	Faulty O ring	Replace all sealing parts.
2. Pressure does not rise.	1) Spring broken 2) Relief valve seat contamination with dust. 3) Seizure in poppet and housing	1) Replace spring. 2) Disassemble and clean poppet and housing. 3) Polish or hone the sliding surface of the poppet and the housing. Or replace the valve set.
3. Pressure unsteady	Faulty relief valve seat	Polish or hone the sliding surface of the poppet and the housing seat, or replace the valve set.

BooK code No. S5 14069 2E

KOBELCO

SHOP MANUAL

HOLDING VALVE (BOOM SAFETY)

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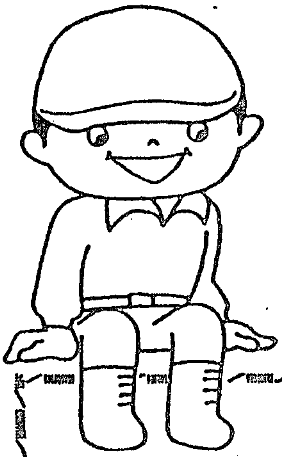


PREFACE

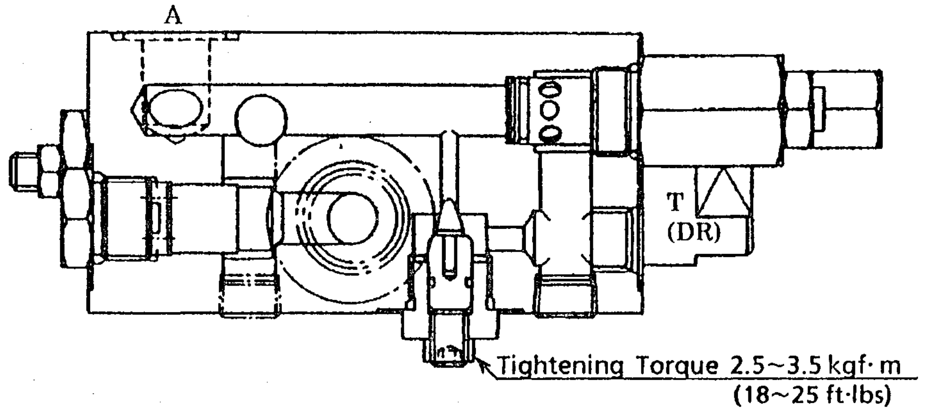
This holding valve is attached to the outlet close to the head side of the boom cylinder and prevents fall of the attachment in case the circuit should burst out.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	June,1990	S5140692E K

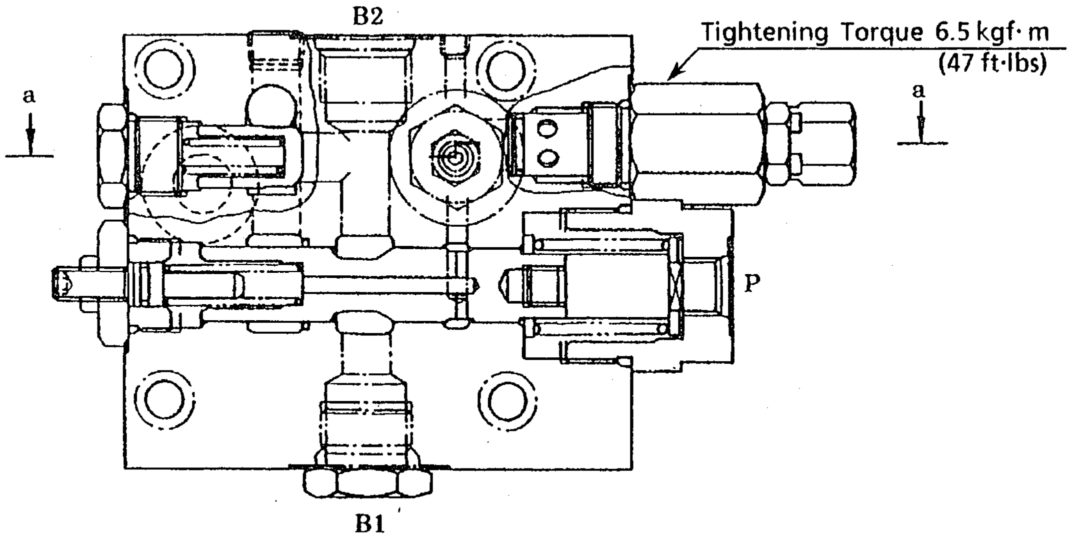
1. SPECIFICATION

1.1 OUTSIDE VIEW



Tightening Torque 2.5~3.5 kgf·m
(18~25 ft·lbs)

Section a-a



Tightening Torque 6.5 kgf·m
(47 ft·lbs)

Fig. 1

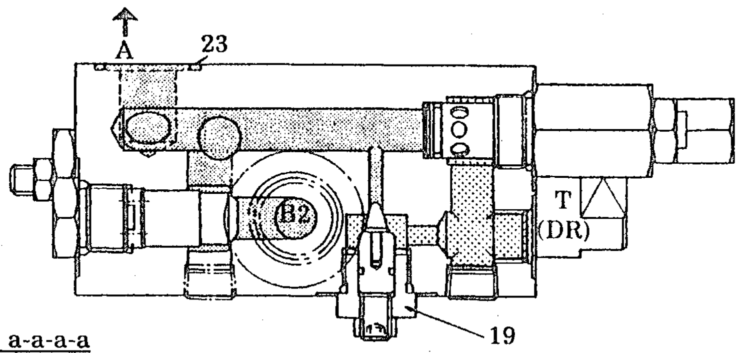
1.2 PRINCIPAL PARTICULARS

Table 1

Specification	Remark	
Model	SHLV - 12	
A port	O ring port	Port on cylinder side
B_1,B_2 port	PF 1/2	Port on pump side
P port	PF 3/8	Pilot port
T (DR) port	PF 3/8	Drain port
Pilot cracking press.	5.1~8.6kgf/cm^2 (73~122 psi) (Adjastable with shim)	
Set press. of overload valve	230Kgf/cm^2 (3270 psi)	

2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION



Section a-a-a-a

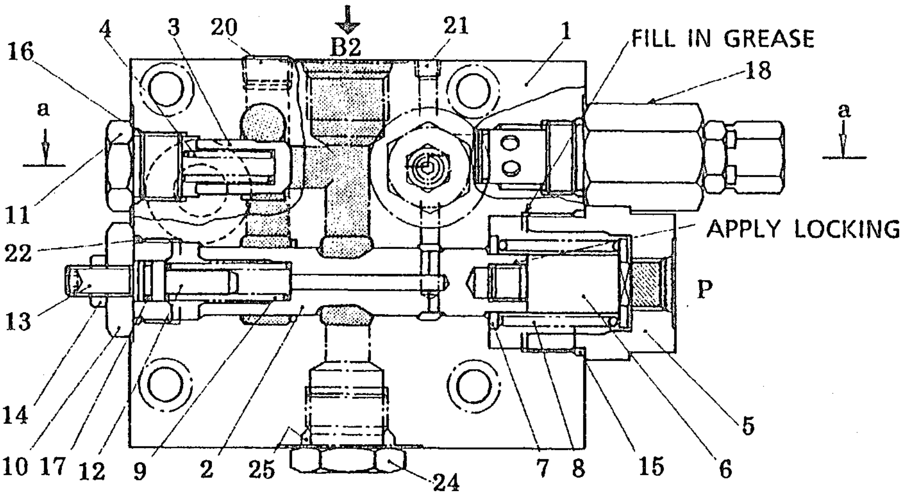


Fig. 2

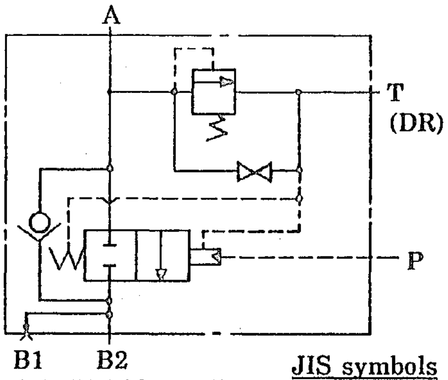
2.2 FUNCTION

(1) Function of poppet (3) in boom hoisting operation
The oil which enters port B of the holding valve pushes up poppet (3), goes out to port A and enters port H of the cylinder.

(2) Transfer of spool (2) in boom lowering operation
The secondary pilot pressure enters port P of the holdeng valve, pushes spool (2) to connect port A with port B and performs lowering of the boom cylinder.

(3) Transfer of spool (2) in case the circuit should burst out
Even if the main circuit after port B should burst out, the secondary pilot pressure to port P ceases to come one boom lowering action is stopped. As the result spool (2) is transferred to the right to shut off the connection between port A and port B.

(4) Function of relief valve (18) that prevents overloads
When the circuit at port A rises over 230kgf/cm^2, (3270 psi) overload relief valve (18) is relieved to prevent the internal pressure of the cylinder from being overloaded.



JIS symbols

No.	NAME	Q'ty	No.	NAME	Q'ty
1	BODY	1	14	NUT	1
2	SPOOL	1	15	O RING	1
3	POPPET	1	16	O RING	1
4	SPRING	1	17	O RING	1
5	PLUG (A)	1	18	OVERLOAD RELIEF VALVE	1
6	SEAT (A)	1	19	STOP VALVE	1
7	SEAT (B)	1	20	PLUG	3
8	SPRING (A)	1	21	PLUG	2
9	SPRING (B)	1	22	O RING	1
10	PLUG (B)	1	23	O RING	1
11	PLUG (C)	1	24	PLUG	1
12	SPRING RETAINER	1	25	O RING	1
13	SOCKET HEAD STOP SCREW	1			

BooK code No. S5 15044 5E

KOBELCO

SHOP MANUAL

HYDRAULIC MOTOR(SWING)

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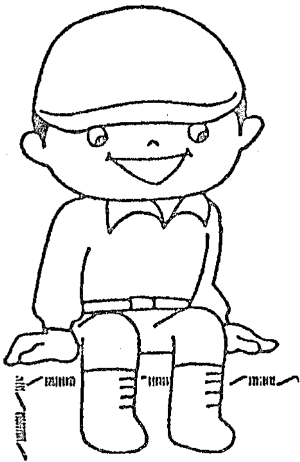
KOBE STEEL, LTD.



PREFACE

This manual deals with a single hydraulic motor (swing). For its duties and functions in an excavator, refer to the separate manual.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	June, 1990	S5150445E K

1. SPECIFICATION

1.1 GENERAL VIEW

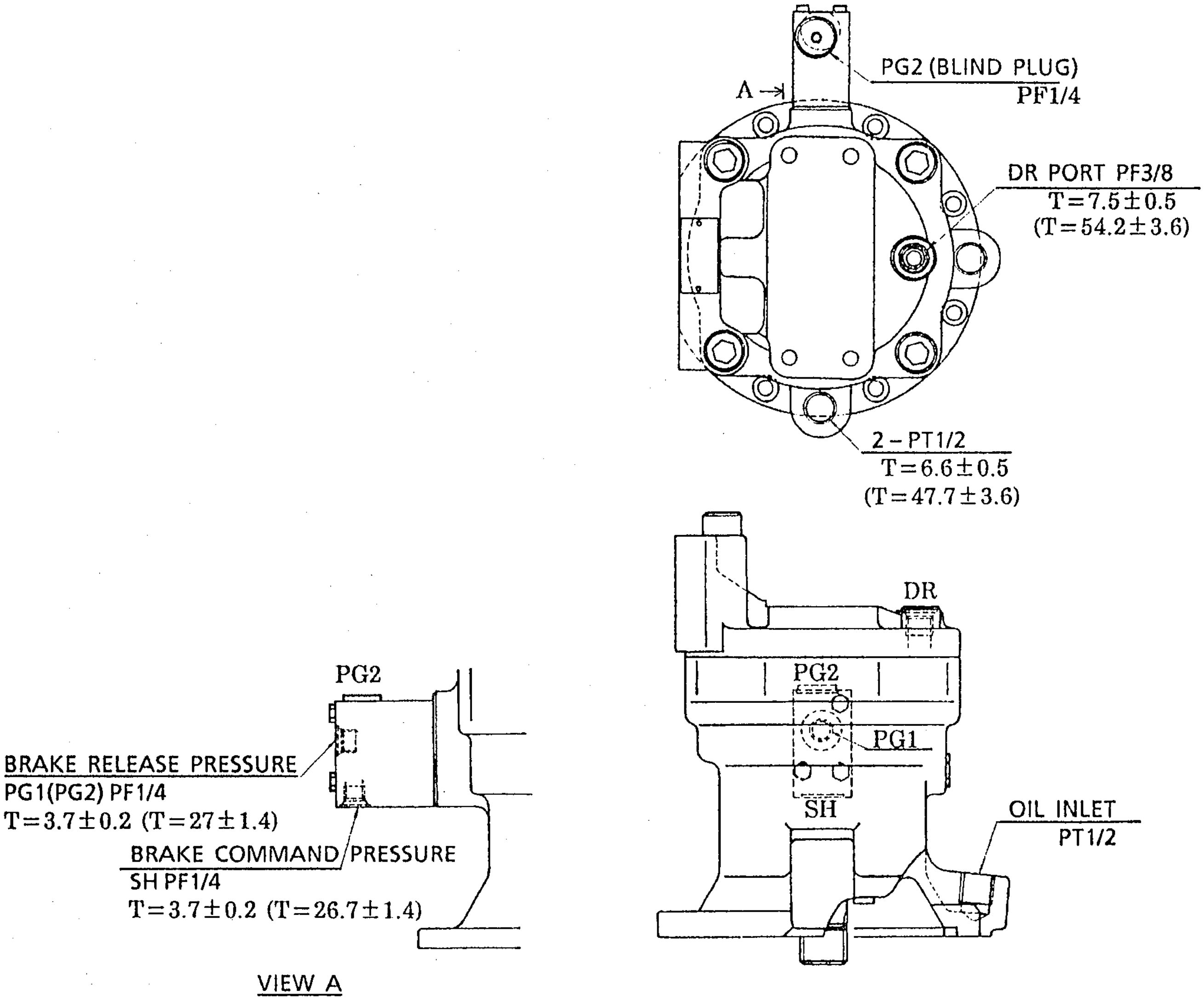

PG2 (BLIND PLUG)
PF1/4
A
DR PORT PF3/8
T=7.5±0.5
(T=54.2±3.6)
2-PT1/2
T=6.6±0.5
(T=47.7±3.6)
DR
PG2
PG1
SH
OIL INLET
PT1/2
PG2
BRAKE RELEASE PRESSURE
PG1(PG2) PF1/4
T=3.7±0.2 (T=27±1.4)
BRAKE COMMAND/PRESSURE
SH PF1/4
T=3.7±0.2 (T=26.7±1.4)
VIEW A

Fig. 1 Outside view of swing motor

1.2 PRINCIPAL PARTICULARS

Table 1

TYPE		M2X55A0B-10A-06M-KSC15R
Displacement	cc/rev (cuin/rev)	56.1 (3.42)
Working pressure	kgf/cm^2 (psi)	250 (3560)
Max. pressure	kgf/cm^2 (psi)	350 (4980)
Max. revolution	rpm	2200
Theoretical torque	kgf·m (ft·lbs)	22.3 (161)
Oil volume in case	ℓ (gal)	0.51 (0.135)
Max. brake torque	kgf·m (ft·lbs)	19.0^{+8}_{0} (137^{+58}_{0})
Relief pressure (stroke-end)	kgf/cm^2 (psi)	22 (313)
Relief pressure (clucking)	kgf/cm^2 (psi)	13 (185)
Weight	kg (lbs)	23 (51)

2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION

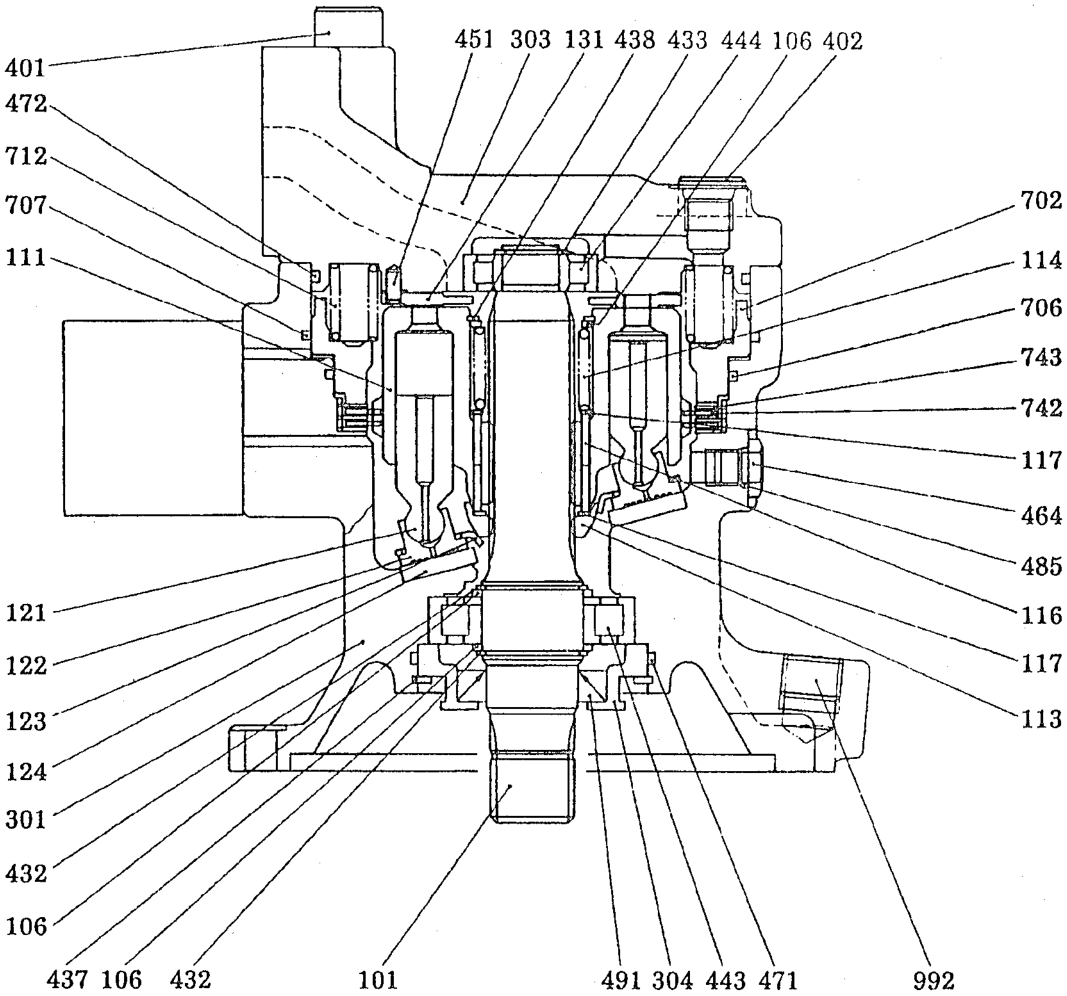

401
472
712
707
111
451
303
131
438
433
444
106
402
702
114
706
743
742
117
464
485
116
117
113
121
122
123
124
301
432
106
437
106
432
101
491
304
443
471
992

Fig. 2

Table 2

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
101	DRIVE SHAFT	1	301	CASING	1	464	VP PLUG	1
106	BEARING SPACER	3	303	VALVE COVER	1	471	O RING	1
111	CYLINDER BLOCK	1	304	FRONT COVER	1	472	O RING	1
113	SPHERICAL BUSHING	1	401	SOCKET BOLT	2	485	O RING	1
114	CYLINDER SPRING	1	402	SOCKET BOLT	2	491	OIL SEAL	1
116	PUSH ROD	12	432	STOP RING	2	702	BRAKE PISTON	1
117	SPACER F	2	433	CIR CLIP (SNAP RING)	1	706	O RING	1
121	PISTON	9	437	LOCKING RING	1	707	O RING	1
122	SHOE	9	438	LOCKING RING	1	712	BRAKE SPRING	20
123	RETAINER PLATE	1	443	ROLLER BEARING	1	742	FRICTION PLATE	2
124	SHOE PLATE	1	444	ROLLER BEARING	1	743	SEPARATE PLATE	3
131	VALVE PLATE	1	451	PIN	2	992	PLUG	2

The motor is of built-in brake axial piston type that have pistons (121) arranged in the same direction as drive shaft (101).

Nine pistons (121) are inserted into the bores of cylinder block (111). Drive shaft (101) is splined to cylinder block (111) and supported with casing (301) by roller bearing (443) (444). Piston (121), the head of which consists of a shoe (122) and a spherical joint, is pressed against shoe plate (124) by means of spherical bush (113), cylinder spring (114) and retainer plate (123).

At both ends of casing (301) are fitted front cover (304) and valve cover (303) having oil inlet and outlet ports. The valve cover (303) consists of valve plate (131) controlling oil flow placed between cylinder block (111) and valve cover (303).

The brake is of wet type single disc construction fixed to the rear side (gear reducer side). It is a negative brake that is actuated by the action of brake spring (712) and is deactuated as brake spring (712) is compressed by pressurized oil.

2.2 FUNCTION

2.2.1 MOTOR SECTION (See fig. 3, Table 3)

As shown in Fig.3, if high pressure oil enters cylinder block (111) by way of IN port (a) of valve plate (131) having a melon-like port, it acts on pistons (121) to create force F in the axial direction. The force F may be divided into force F_1 vertical to shoe plate (124) via shoe (122) and force F_2 at right angles with the shaft. The force F_2 is transmitted to cylinder block (111) via pistons (121) and causes drive shaft (101) to turn so as to produce a rotating couple.

The cylinder block (111) has nine pistons (121) equally arranged. Rotating torque is transmitted to drive shaft (101) by turns by piston (121) connected to inlet port (a) of high pressure oil.

If the oil incoming and outgoing directions are reversed, the drive shaft (101) rotates in the opposite direction.

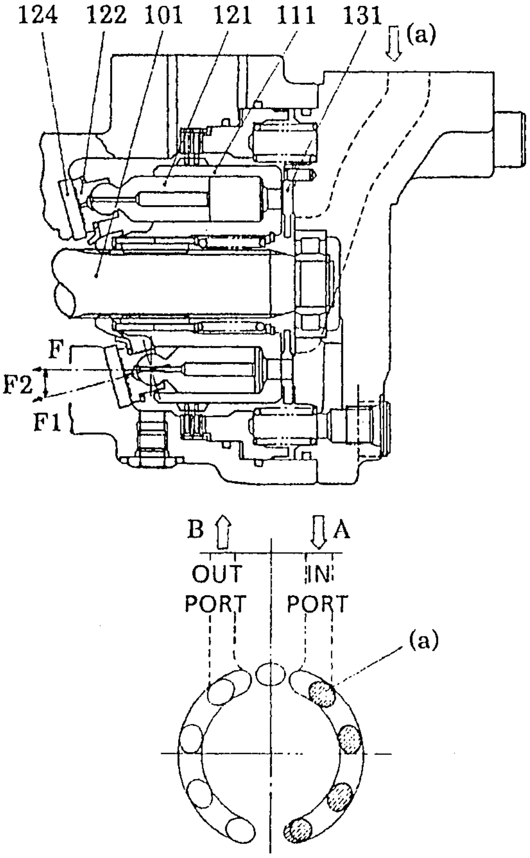
Theoretical output torque T can be given by the following equation:

$$T=\frac{Q\times P}{2\pi 100}$$

Where T: Output torque (kgf·m)

P: Effective differential pressure (kgf/cm^2)

Q: Displacement per revolution (cc/rev)



AS VIEWED FROM THE SHAFT SIDE

Fig. 3

Table 2

Rotating direction (as seen from shaft side)	Left	Right
Pressure oil inlet	B	A
Pressure oil outlet	A	B

2.2.2 BRAKE SECTION (See Fig. 4.)

The cylinder (111) is jointed by drive shaft (101) and a spline. Separator plate (743) is bound in its circumferential direction by circular grooves provided in casing (301).

Now, if the friction plate (742) splined to the outer circumference of the cylinder is pressed against casing (301) via separate plate (743) and brake piston (702) by the action of brake spring (712), frictional force is created between friction plate (742) and casing (301) and between separator plate (743) and brake piston (702). The frictional force bounds the drive shaft to brake the motor. In the meantime, when brake release pressure applied to the oil chamber formed between brake piston (702) and casing (301) overcomes the spring force, the brake is released as brake piston (702) moves till friction plate (742) is detached from casing (301).

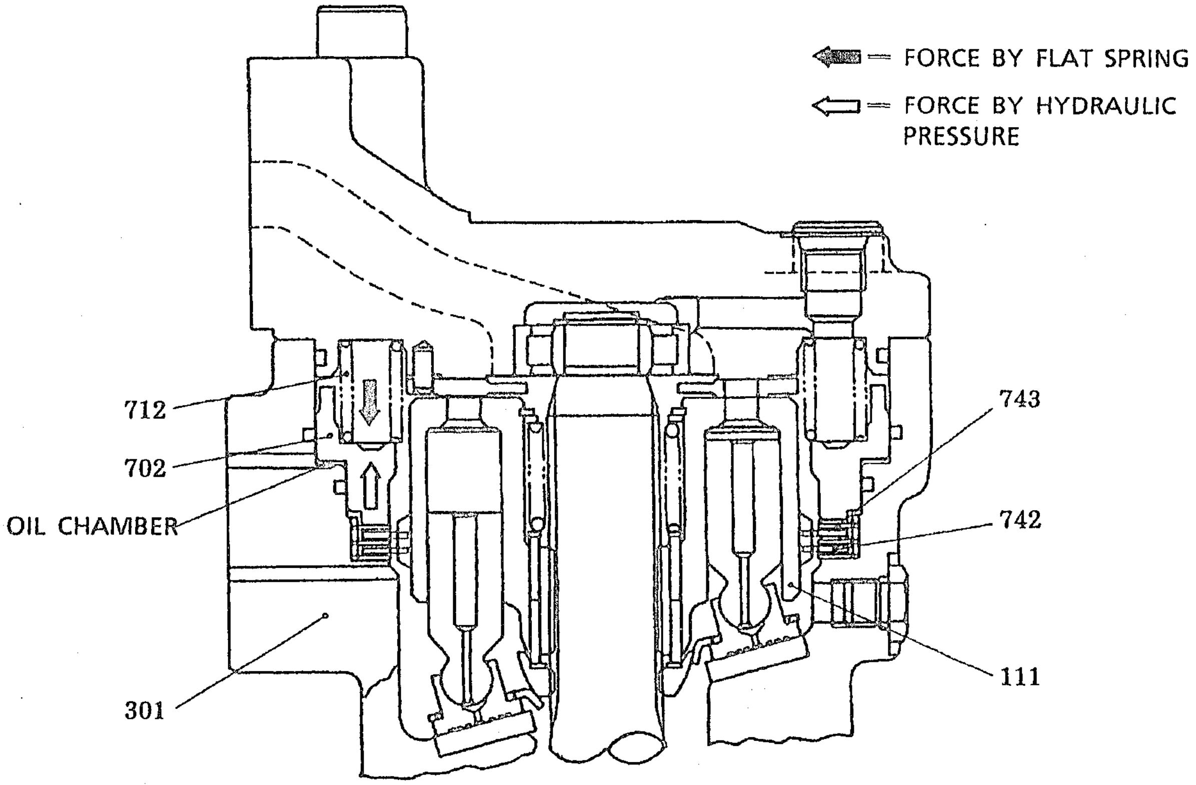

FORCE BY FLAT SPRING
FORCE BY HYDRAULIC PRESSURE
712
702
OIL CHAMBER
301
743
742
111

Fig. 4

3. DISASSEMBLY AND ASSEMBLY

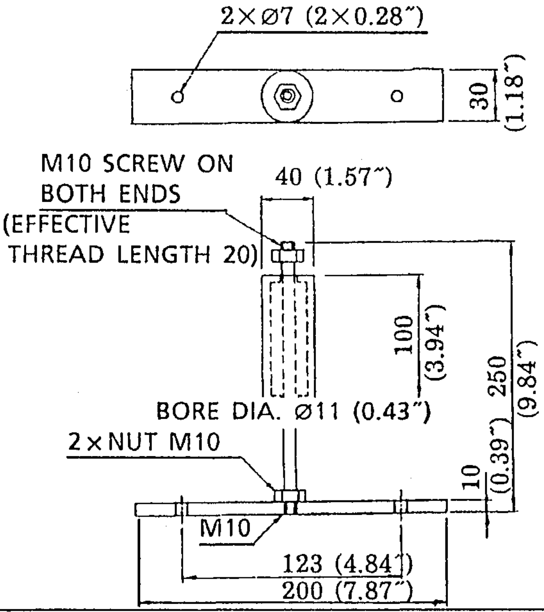
This chapter deals with disassembly and reassembly procedures of a motor with a brake.

3.1 TOOLS AND JIGS

Table 4 (1/2)

Tool		Remarks
Socket wrench	VP Plug	VP1/4 (Width across flats) 19mm (0.75in)
Allen key wrench		M16 (Width across flats) 14mm (0.55in)
Pliers	For front cover fixing locking rings	For snap ring, for hole Ø80mm (Ø3.15in)
	For inner race spacer fixing stop ring	For snap ring, for shaft Ø35mm (Ø1.38in)
	Screwdriver	Flat-bladed type, medium size 2 pcs.
Steel bar		10mm×8mm×200mm (0.39in×0.31in×7.87in) (Key material) 1 pc.
Hammer		Plastic mallet, and iron hammer 1 ea.
Torque wrench		1~4.5kgf·m (7.2~33 ft·lbs) 12~48kgf·m (87~350 ft·lbs)
Slide Hammer		

Table 4 (2/2)

Jig	Remarks
1. Items to be prepared Brake piston drawing jig, Refer to "Application" column. Bolt M10×75 2pcs 2. Handling procedure 1. Put two M7×75 bolts into two Ø7 holes in the bar part of the jig by way of the cylindrical part. 2. In this condition, screw in two M7 bolts into the brake piston drawing bolt holes. On that occasion, tighten bolts evenly. 3. Grasp the cylindrical part of the jig and pull it straight up in a breath. 4. Draw the brake piston with the jig out of the casing, repeating this action. 3. Caution ● Tighten M10 nuts (529 places) securely. ● When using the jig, exercise care so as not to pinch your hand between the cylindrical part and the M10 nuts.	 2×Ø7 (2×0.28") 30 (1.18") M10 SCREW ON BOTH ENDS (EFFECTIVE THREAD LENGTH 20) 40 (1.57") 100 (3.94") 250 (9.84") BORE DIA. Ø11 (0.43") 2×NUT M10 10 (0.39") M10 123 (4.84") 200 (7.87")

3.2 DISASSEMBLY

3.2.1 GENERAL PRECAUTIONS

1) Since hydraulic components are precision machined to minimal clearance, disassemble and assemble them in a less dusty, clean place. Handle them with care, using clean tools and cleaning oil.

2) When the motor is removed from the machine body, clean the area around ports and put plugs to them so as to prevent entry of water inside.

   When refitting it to the machine, do not remove plugs till piping is complete.

3) Before starting operation, study the structural drawings and prepare necessary parts according to your purpose and the extent of operation. Seals and O rings once removed can not be reused.

   There are some parts which can oily be supplied in sub-assemblies. Prepare such parts in advance, looking up parts catalogs.

4) Each of the piston is matched to specific bore of the cylinder block when new. If you wish to reuse them, leave a matching mark to them when separating pistons from the cylinder block.

3.2.2 DISASSEMBLY PROCEDURE

The numbers in parentheses after part names in the instructions correspond to those in the structural drawing (Fig. 2).

1) Remove the drain plug and drain hydraulic oil out of the casing (301).

2) Direct the shaft end of the drive shaft (101) down and fix it on a bench convenient for disassembly. On that occasion, leave a matching mark on the mating part between casing (301) and valve cover (303).

☞ Choose a clean place. Place a rubber sheet or a cloth on the bench for disassembly. Exercise care so as not to damage parts.

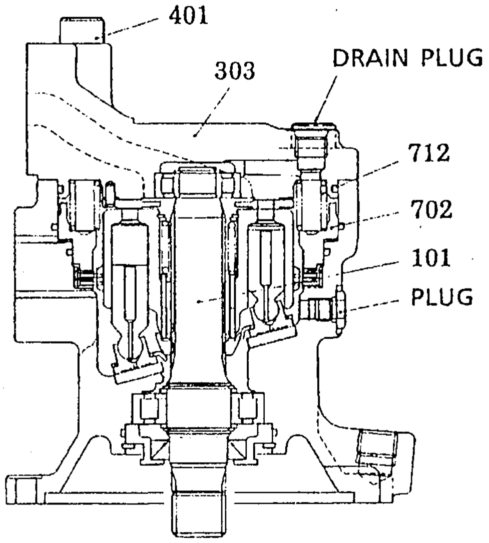


Fig. 5 Drawing out the brake pistons (702)

3) Loosen socket bolt (401) and separate valve cover (303) form casing (301). If the socket bolt (401) are take off, the valve cover floats off casing (301) by the action of brake spring (712).
4) Separate valve plate (131) and O ring (472) from valve cover (303). (See Fig. 2.)

☞ Valve plate (131) may come off together in the step 3).

5) Draw out brake spring (712) from brake piston (702).

6) Place the motor level and draw out the cylinder (111) from the drive shaft (101). Then draw out piston (121), retainer plate (123), spherical bush (113), spacer F (117) and shoe plate (124).

☞ Handle cylinder block (111), spherical bush (113) and shoe (122) so as not to prevent the sliding surfaces from being damaged.

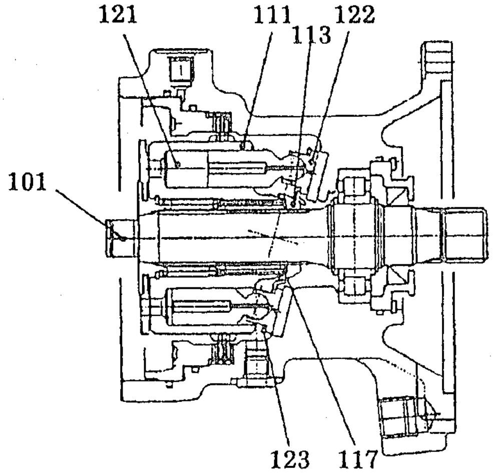


Fig. 6 Drawing out cylinder block (111)

7) Draw out friction plate (742) and separator plate (743) from casing (301).
8) Remove locking ring (437) by means of pliers and separate front cover (304) from casing (301).

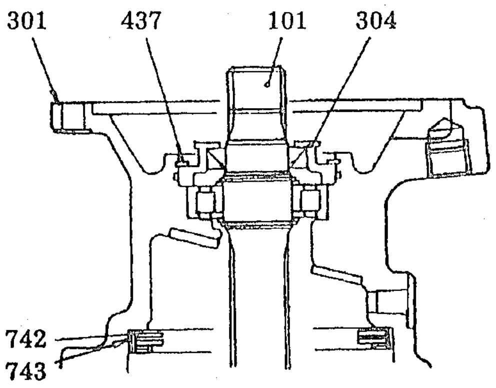


Fig. 7 Removing front cover (304)

9) Separate drive shaft (101) from casing (301) by lightly tapping the end face of the valve cover side (303) of drive shaft (101), using a plastic mallet.

☞ When drawing out the front cover (304), exercise care so as not damage the sliding surface of the oil seal.

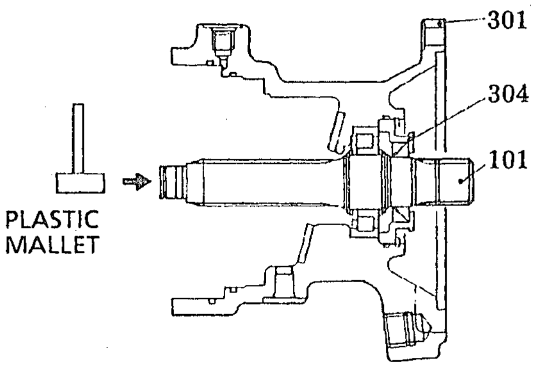


Fig. 8 Drawing out drive shaft (101)

10) Draw out casing (301) by lightly tapping shoe plate (124) through the housing of the roller bearing (443) in the casing (301) by means of a copper bar, so as not to damage the shoe plate (124).

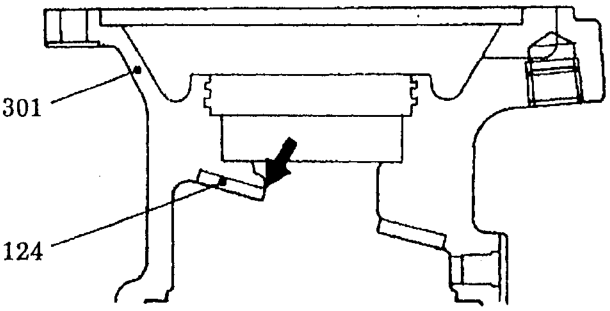


Fig. 9 Drawing out shoe plate (124)

11) Perform the following disassembly operation only when necessary.
   a) Remove stop ring (432) and spacer (106) from driver shaft (101) and extract the inner race of roller bearing (443), utilizing a press.

☞ You can tap the inner race of roller bearing (443) via a copper bar. Use care so as not to damage the bearing by tapping the inner race evenly all around.

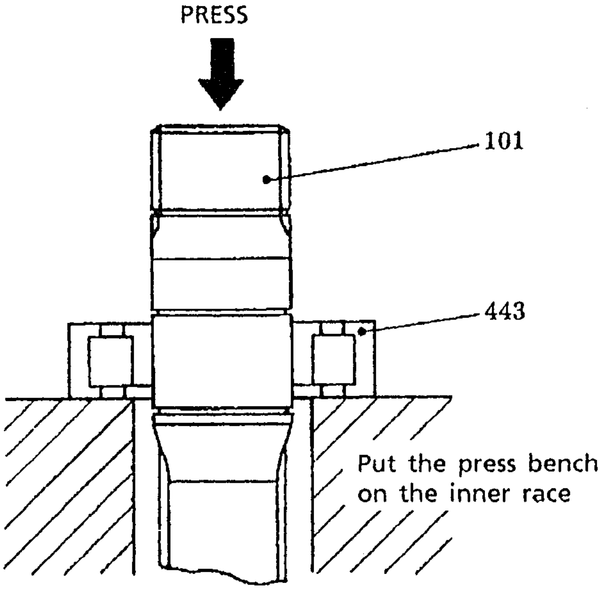


Fig. 10 Drawing out the inner race of roller bearing (443)

   b) Draw out oil seal (491) from front cover (304), utilizing a jig.

☞ Do not reuse the drawn-out oil seal.

   c) Separate needle bearing (444) from valve cover (303) using a slide hammer bearing puller.

☞ Do not reuse the bearing once removed.

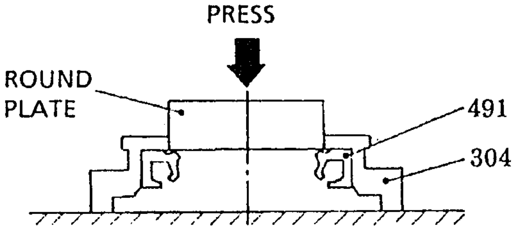


Fig. 11 Drawing out oil seal (491)

3.3 ASSEMBLY

3.3.1 GENERAL PRECAUTIONS

1) Repair damaged parts after disassembly and prepares replacement parts beforehand.
2) Wash each part thoroughly with cleaning oil and dry it with jet air.
3) Always coat sliding parts with clean hydraulic oil before assembly.
4) Replace seals such as O rings and oil seals in principle.
5) Use a torque wrench to tighten socket bolts and plugs to a specified torque.

3.3.2 ASSEMBLY PROCEDURE

The numbers in parentheses after part names in the instructions correspond to those in the structural drawing (Fig. 2).

1) Fit stop ring (432) and bearing spacer (106) to the drive shaft (101), insert bearing spacer (106) to it, and then insert the flange of the roller bearing (443). Heat the inner race to 100~120°C (212~248°F), put bearing spacer (106) in and fit the stop ring.

☞ Insert the R side of the bearing to the bearing spacer side.

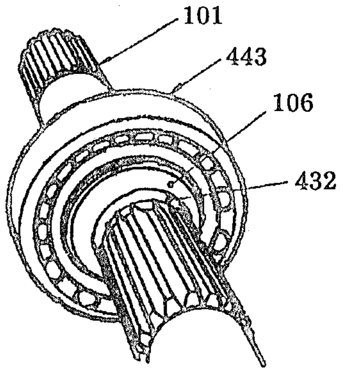


Fig. 12

2) Heat the inner race of the roller bearing (444) to 100~120°C (212~248°F) and fit cir clip (443) to drive shaft (101).

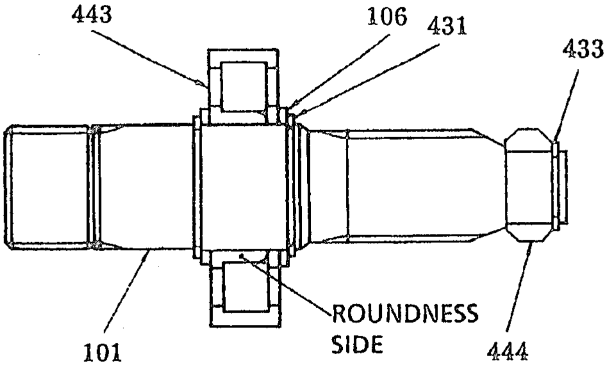


Fig. 13

3) Direct the drive shaft (101) fitted with roller bearing (443) into casing (301) with its output shaft side up and fit the roller bearing (443) by lightly tapping its outer race with a hammer via a copper bar.

☞ Strike the outer circumference of the outer race evenly all round till it stops at the terraced part of the casing.

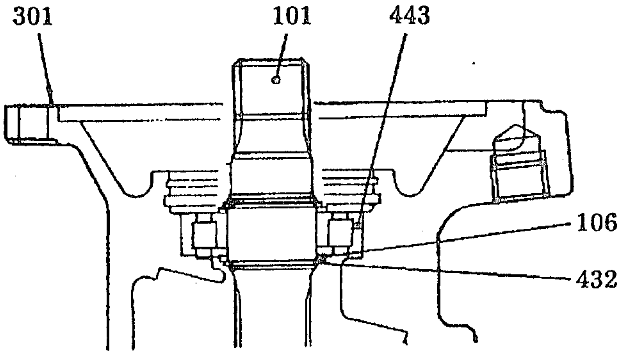


Fig. 14

4) Put oil seal (491) into front cover (304), using a jig, fit O ring (471) to casing (301) and fix front cover (304) to casing by lightly tapping it with a plastic mallet.

5) Fix locking (437) to casing (301), using pliers.

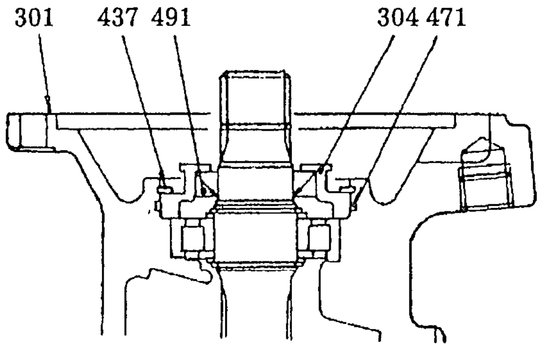

301
437 491
304 471

Fig. 15

6) Place casing (301) level and insert shoe plate (124).

☞ Fit the larger chamfered part of shoe plate (124) to the casing side.

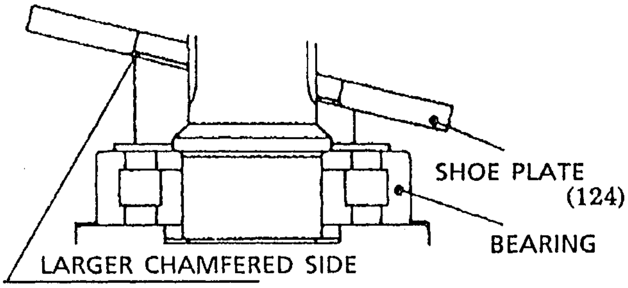

SHOE PLATE
(124)
BEARING
LARGER CHAMFERED SIDE

Fig. 16

7) Fit push rod (116) to cylinder block (111). Then mount the spherical bush (113) with spacer F (117) on the cylinder and set piston (121) and shoe (122) to retainer plate (123).

8) Assemble piston (121) and shoe (122) fixed to retainer plate (123) into cylinder block (111) and fix them to the spline of drive shaft (101).

☞ Use care so as not to score the sliding surface of the cylinder. (Insert two push rods (116) into one hole.)

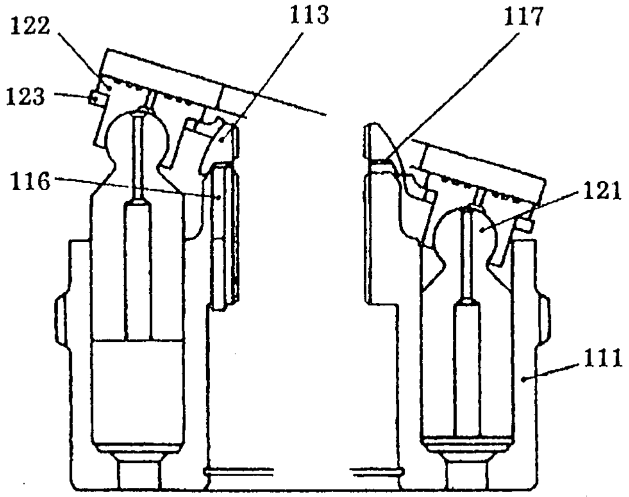

122
113
117
123
116
121
111

Fig. 17 Cylinder block ass'y

9) Reposition the casing (301) (orientation of Fig. 18) with the front cover (304) facing down, and fit separator plate (743) and friction plate (742) to casing (301) in that order.

10) Fit three separator plates (743) and two friction plates (742).

☞ Fit one friction plate (742) over another so four cutouts on the gears match vertically.

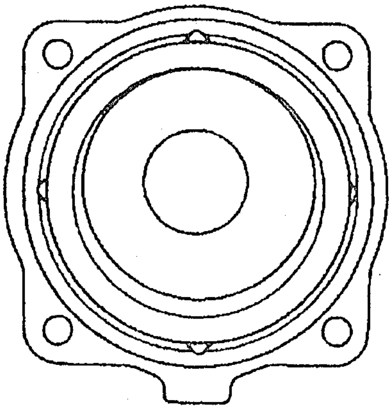


Fig. 18 Changing the orientation of casing (301)

11) Fix O rings (706,707) to casing (301).

12) Fix brake piston (702) into the casing and fit brake spring (712).

☞ ◎ Fit the four slits on the brake piston (702) in the position shown in Fig. 20.
◎ When the brake piston (702) is hard to enter due to the resistance of O rings, screw in a M8 socket bolt into the brake piston and knock it evenly by means of a plastic mallet.
◎ Confirm that the brake spring is fitted securely in the spot facing of the brake piston (702).

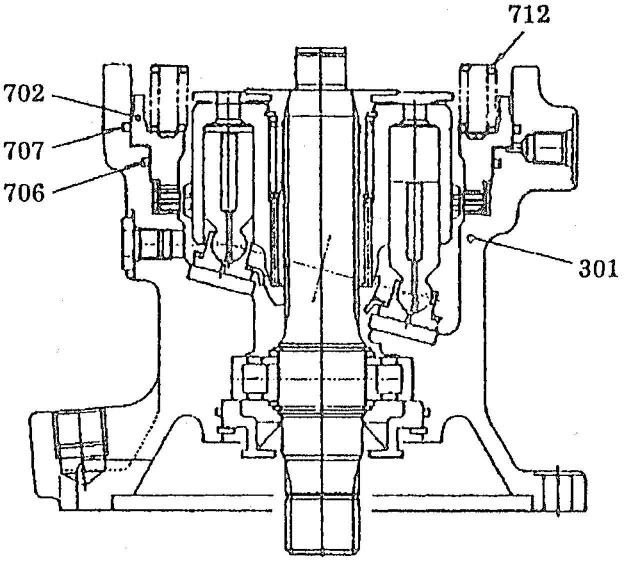


Fig. 19 Assembling the brake piston

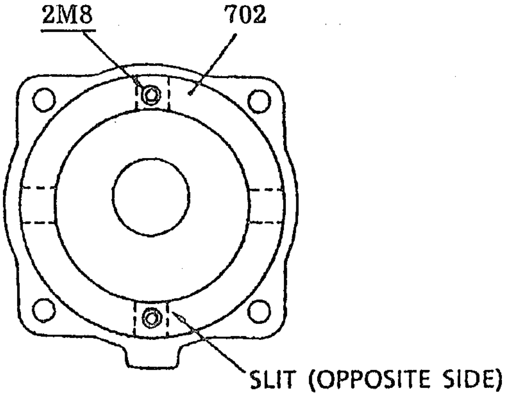


Fig. 20

13) Fix valve plate (131) to valve cover (303) and fit O ring (472) then.

14) Attach valve cover (303) to casing (301) and tighten socket head capscrews (401, 402) to a specified torque. (tightening torque : 2.4kgf · m (17 lbs))

☞ • Notice the direction in which the valve plate (131) is to be fitted. (Direct the roundness part of the valve plate in the opposite direction of the flange.)

- Coat the jointing surface of the valve plate (131) with a thin film of grease.
- Use care so that the brake spring (712) does not come off.
- Exercise care so that the brake spring (712) may not fall down.
- Tighten socket bolt (401) evenly all around.

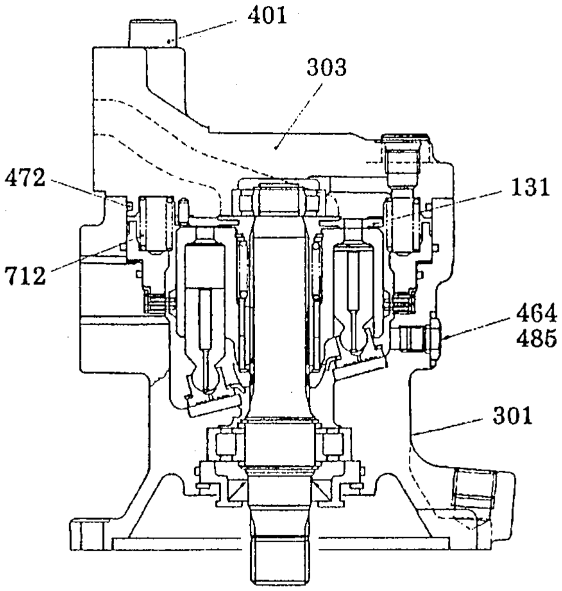


Fig. 21

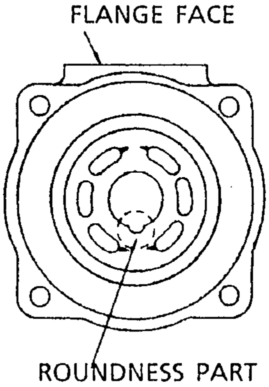


Fig. 22

15) Fit O ring (485) to plug (464) and fasten the plug to casing (301).

This completes assembly. Fill clean hydraulic oil into the suction port and the piston shoe side.

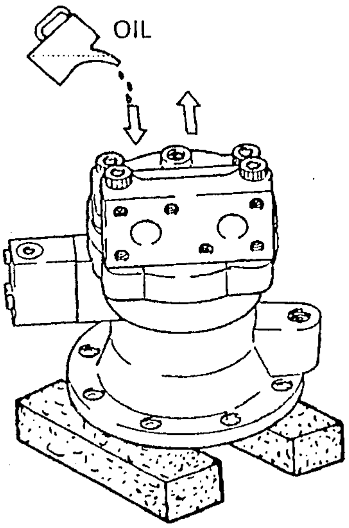


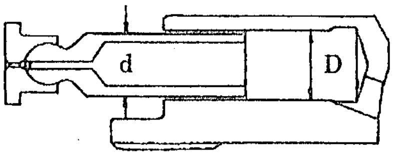
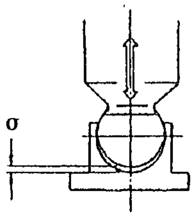
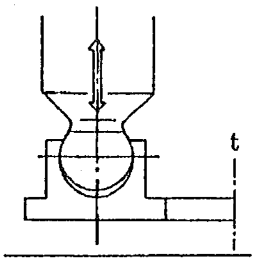
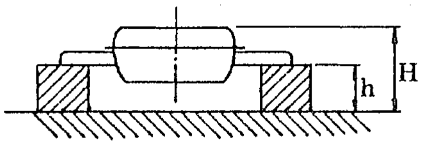
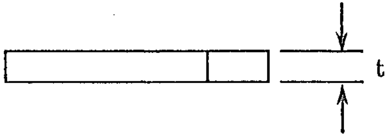
Fig. 23 Method of lubrication

4. SERVICE STANDARDS

4.1 STANDARD FOR PARTS SERVICE AND REPLACEMENT

The following lists standards of the serviceability of parts to be determined from measurements made at disassembly. However, they are general standards and when parts show excessive external damage or discoloration, top priority should be given to the determination of an extent to which parts are to be replaced, according to the purpose of disassembly and the remaining life expectancy of the parts.

Table 5

Item	Standard Dimension mm (in)	Recommended Value for Replacement mm (in)	Remedy
Clearance between piston and cylinder bore (D-d)  	0.016 (0.0006)	0.046 (0.002)	Replace piston or cylinder.
Gap between piston and caulked part of shoe (σ)  	0	0.3 (0.012)	Replace piston shoe assembly.
Thickness of shoe (t)  	4 (0.1575)	3.8 (0.150)	Replace piston shoe assembly.
As-assembled height of retainer plate and spherical bush (H-h)  	5.5 (0.2165)	5.0 (0.197)	Replace a spherical bush and a retainer plate as a pair.
Thickness of friction plate  	3.5 (0.1378)	3.1 (0.122)	Replace.

4.2 STANDARD FOR CORRECTING SLIDING SURFACES

If the surface roughness of the sliding surface of a part exceeds the following standard, correct it or replace the part.

Table 6

Name of part	Standard surface roughness	Surface roughness requiring correction
Shoe	0.8-Z (Ra=0.2) (lapping)	3-Z (Ra=0.8)
Shoe plate	0.4-Z (Ra=0.1) (lapping)	3-Z (Ra=0.8)
Cylinder	1.6-Z (Ra=0.4) (lapping)	12.5-Z (Ra=3.2)
Valve plate	0.8-Z (Ra=0.2) (lapping)	6.3-Z (Ra=1.6)

☞
- Lap each sliding surface to a standard roughness level or finer.
- If the sliding surface of the cylinder block, valve plate, retaining plate or spherical bush is roughened, replace parts in pairs.

5. TROUBLESHOOTING

5.1 GENERAL PRECAUTIONS

Given below are actions to be taken when you have found any abnormality on the hydraulic motor during operation:

(1) Think about this before proceeding to work.
Before proceeding to work, determine the nature of the fault and think if the same symptom that occurred before. Think once again if the fault really results from the motor.

(2) Beware of dust.
Many faults result from dust. Therefore take adequate measures at disassembly to prevent entry of dust.

(3) Handling parts
Parts are precision finished and sufficient care should be taken in handling so as not to damage parts.
It is recommended during disassembly to replace O rings with new ones.

5.2 FAULT FINDING OF MOTOR PROPER

It is extremely difficult to find causes of trouble of the hydraulic circuits. Inspect the following items and investigate whether or not the fault really comes from the motor.

(1) Inspecting the oil in casing
Remove the drain plug and inspect the hydraulic oil in the casing. If a large amount of metallic particles come out with oil, you should suspect of a failure of motor interior parts.

(2) Presence of abnormal noise
Check whether the motor emits an abnormal noise or not.

(3) Pressure measurement of various points
Measure pressures at various points and check for faults, in stead of disassembling parts at random.

5.3 TROUBLESHOOTING

(1) Hydraulic motor does not rotate.

Table 7

Trouble	Cause	Remedy
Pressure does not rise.	1. Safety valve in circuit is not set correctly.	1. Set to correct value.
Pressure rises.	1. Overload 2. Moving parts are seized. 3. Brake release pressure is not working on the motor 4 Brake piston is stuck. 5. Friction plate is seized.	1. Eliminate overload. 2. Inspect and repair piston, shoe, cylinder block and valve plate. 3. Check circuit and correct it. 4. Disassemble and check. 5. Disassemble, check and repair.

(2) Rotating direction is opposite.

Table 8

Trouble	Cause	Remedy
Rotating direction is opposite.	1. Motor's rotating direction is reversed. 2. Piping inlets and outlets are reversed.	1. Assemble correctly. 2. Pipe correctly.

(3) Revolution does not rise to set value.

Table 9

Trouble	Cause	Remedy
Revolution does not rise to set value	1. Oil inflow is deficient. 2. Oil leaks are excessive due to high temperature. 3. Sliding surfaces are worn or broken.	1. Check pump's discharge rate and circuits to motor. 2. Lower oil temperature. 3. Replace.

(4) Oil leaks

1) Oil leak from oil seal

Table 10

Trouble	Cause	Remedy
Oil leaks from oil seal	1. Lip of seal contains dirt and damaged. 2. Shaft is damaged or worn. 3. Casing inner pressure has risen abnormally high, with the result that lip of oil seal has turned up. 4. Shaft is rusted.	1. Replace oil seal. 2. Shift the lip and shaft positions or replace oil seal. 3. Repair drain piping if clogged up. 4. Disassemble and correct.

2) Oil leak from matching surface

Table 11

Trouble	Cause	Remedy
Oil leak from matching surface	1. O ring is missing. 2. O ring has a scratch. 3. Seal surface has a scratch. 4. Bolt is loose or broken.	1. Set O ring correctly and assemble it. 2. Replace. 3. Disassemble and correct. 4. Tighten to specified torque or replace.

(5) Brake torque is insufficient.

Table 12

Trouble	Cause	Remedy
Brake torque is insufficient.	1. Friction plate is worn. 2. Brake piston is stuck. 3. Brake release pressure is not released. 4. Spline of friction plate is broken.	1. Disassemble and check. Replace if wear is beyond standard value. 2. Disassemble and check. 3. Check and correct circuit. 4. Disassemble and check. Replace broken part.

Book code No. S5 15045 1E

KOBELCO

SHOP MANUAL

HYDRAULIC MOTOR (TRAVEL)

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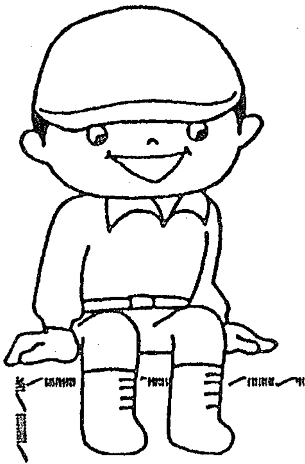
KOBE STEEL, LTD.



PREFACE

This manual covers the hydraulic motor (travel).
The hydraulic motor consists of a motor, a reduction gear and a brake valve assembled in one piece. Furthermore, the hydraulic motor is equipped with a high-low changeover mechanism and a parking brake.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	June,1990	S5150451E K

1. SPECIFICATIONS

1.1 GENERAL VIEW

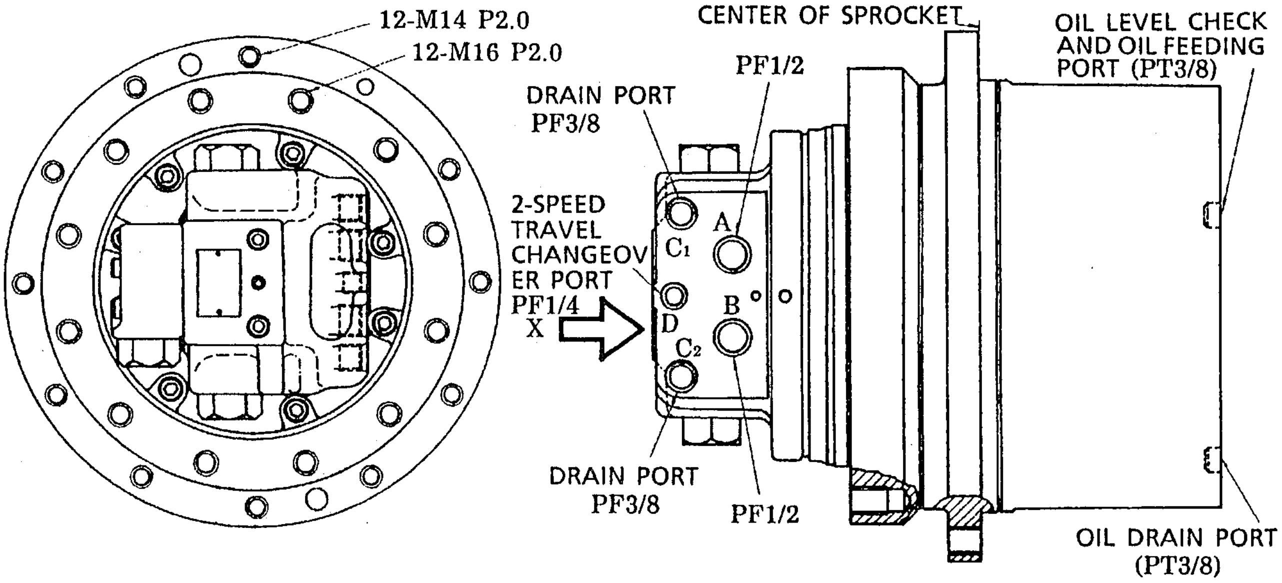

12-M14 P2.0
12-M16 P2.0
DRAIN PORT PF3/8
2-SPEED TRAVEL CHANGEOVER PORT PF1/4
X
CENTER OF SPROCKET
PF1/2
A
C₁
B
D
C₂
DRAIN PORT PF3/8
PF1/2
OIL LEVEL CHECK AND OIL FEEDING PORT (PT3/8)
OIL DRAIN PORT (PT3/8)

Fig. 1 Outside View of Travel Motor (with Reduction unit & Brake Valve)

Rotating direction (As seen from X side)	Oil inlet	Oil outlet
CW	A	B
CCW	B	A

1.2 SPECIFICATION

Table 1

Item		Model	GM09VL-E-24/38-1
Reduction Unit	Reduction ratio		62.4
	Output torque	kgf · m (ft · lbs)	543/871 (3920/6290)
	Revolution	rpm	52.8/33.6
	Lube oil		API Class CD SAE30
	Oil capacity		1.7ℓ (0.45gal)
Motor	Max. stroke displacement	cc / rev (cuin / rev)	38.3 (2.34)
	2-speed changeover pressure	kgf / cm^2 (psi)	15 (213)
Parking Brake	Braking torque	kgf · m (ft · lbs)	8.4 (61)
	Brake release pressure	kgf / cm^2 (psi)	9 (128)
Brake Valve	Model		B08B-D-1
Total weight		kg (lbs)	90 (198)

2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION

2.1.1 BASIC CONSTRUCTION

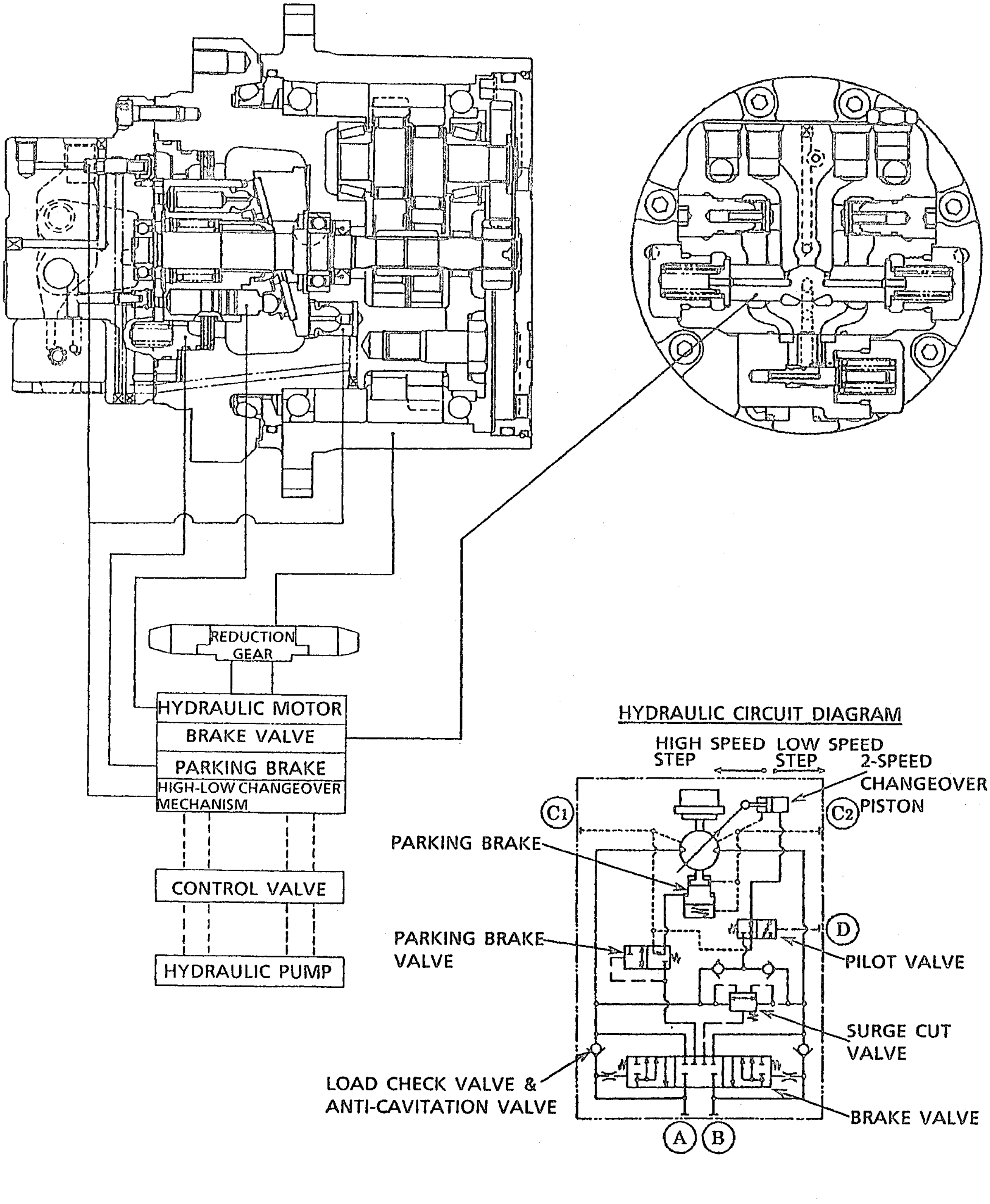

REDUCTION GEAR
HYDRAULIC MOTOR
BRAKE VALVE
PARKING BRAKE
HIGH-LOW CHANGEOVER MECHANISM
CONTROL VALVE
HYDRAULIC PUMP
HYDRAULIC CIRCUIT DIAGRAM
HIGH SPEED STEP
LOW SPEED STEP
2-SPEED CHANGEOVER PISTON
C1
C2
PARKING BRAKE
PARKING BRAKE VALVE
D
PILOT VALVE
SURGE CUT VALVE
LOAD CHECK VALVE & ANTI-CAVITATION VALVE
BRAKE VALVE
A
B

Fig. 2

2.1.2 HYDRAULIC MOTOR

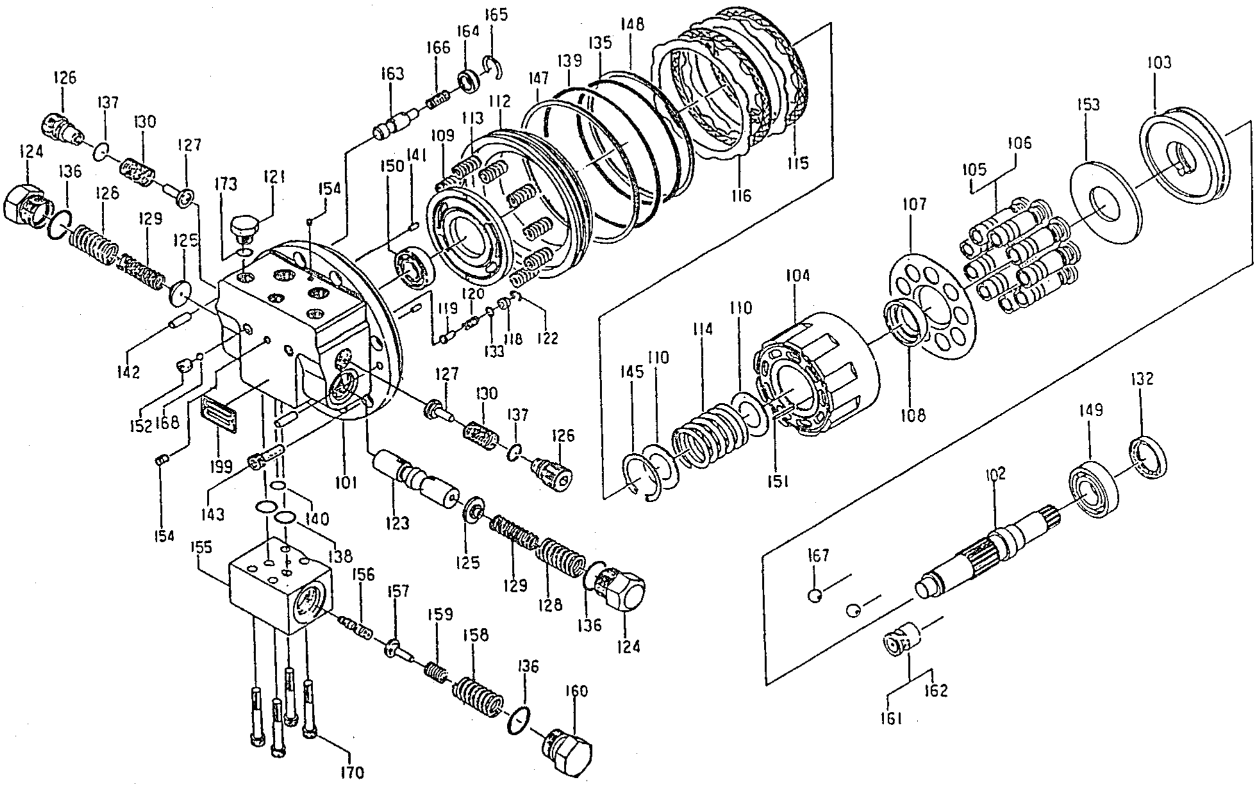

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Fig. 3

No.	NAME	Q'ty	No.	NAME	Q'ty	No.	NAME	Q'ty
101	REAR FLANGE	1	125	SPRING RETAINER	2	151	NEEDLE ROLLER	3
102	DRIVE SHAFT	1	126	PLUG	2	152	PLUG	2
103	(SWASH) PLATE	1	127	ANTI-CAVITATION VALVE	2	153	THRUST PLATE	1
104	CYLINDER BLOCK	1	128	SPRING	2	154	EXPANDER	2
105	PISTON	1	129	SPRING	2	155	SURGE CUT VALVE	1
106	SHOE	1	130	SPRING	2	156	SPOOL	1
107	RETAINER PLATE	1	132	OIL SEAL	1	157	STOPPER	1
108	THRUST BALL	1	133	O-RING	1	158	SPRING	1
109	PLATE	1	135	O-RING	1	159	SPRING	1
110	WASHER	2	136	O-RING	3	160	PLUG	1
112	PISTON	1	137	O-RING	2	161	PISTON	1
113	SPRING	8	138	O-RING	2	162	SHOE	1
114	SPRING	1	139	O-RING	1	163	PILOT VALVE	1
115	PLATE (FRICTION PLATE)	2	140	O-RING	1	164	STOPPER	1
116	PLATE (COMPANION PLATE)	2	141	PARALLEL PIN	2	165	RING	1
118	VALVE SEAT	1	142	PARALLEL PIN	2	166	SPRING	1
119	VALVE	1	143	SOCKET BOLT	8	167	BALL	2
120	SPRING	1	145	SNAP RING	1	168	BALL	2
121	PLUG	1	147	BACKUP RING	1	170	SOCKET BOLT	4
122	RING	1	148	BACKUP RING	1	173	O-RING	1
123	BRAKE VALVE SPOOL	1	149	BEARING	1	199	NAME PLATE	1
124	PLUG	2	150	BEARING	1			

2.1.3 REDUCTION UNIT

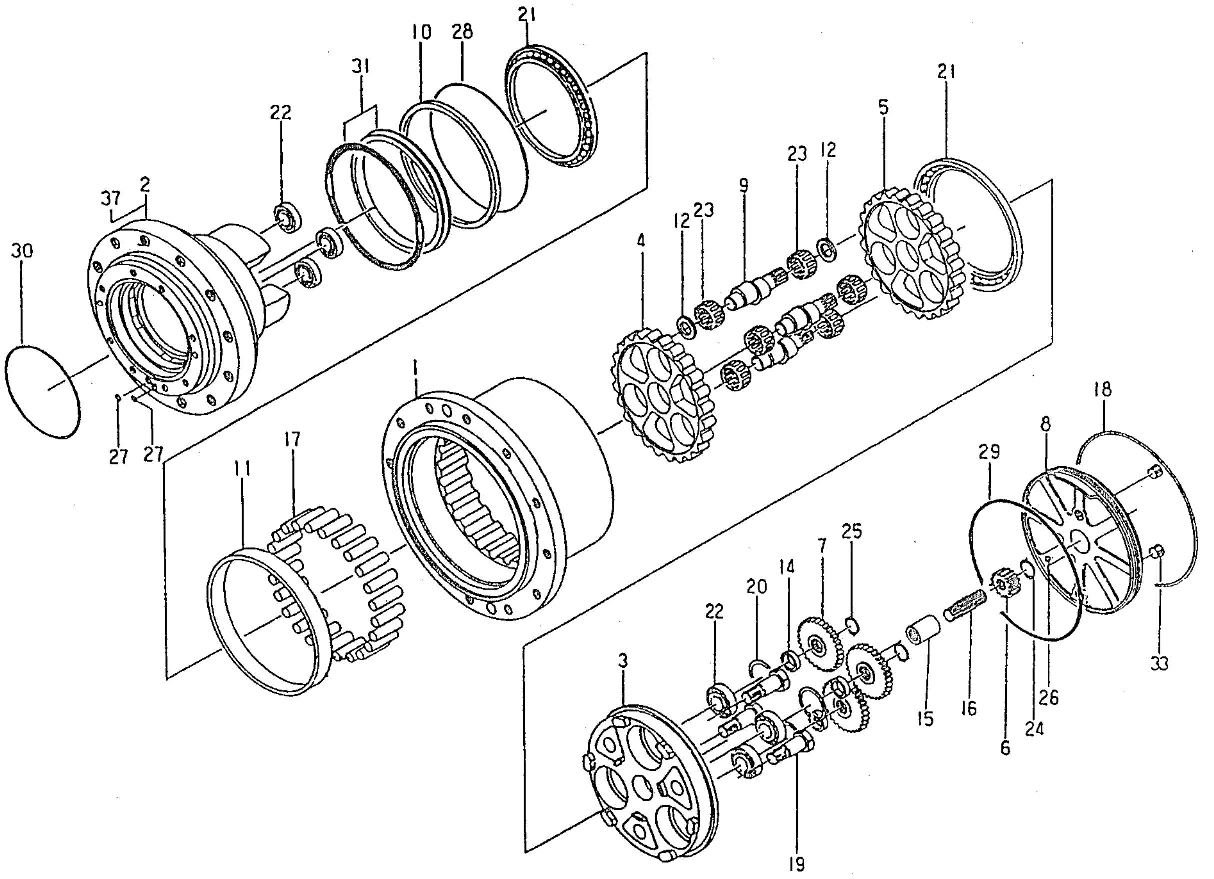
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Fig. 4

No.	NAME	Q'ty	No.	NAME	Q'ty
1	HUB	1	18	RING	1
2	SPINDLE	1	19	REAMER BOLT	3
3	HOLD FLANGE	1	20	SNAP RING	3
4	RV GEAR A	1	21	BEARING	2
5	RV GEAR B	1	22	BEARING	6
6	INPUT GEAR	1	23	BEARING	6
7	SPAR GEAR	3	24	SNAP RING	1
8	COVER	1	25	SNAP RING	3
9	CRANK SHAFT	3	26	BALL	1
10	DISTANCE PIECE	1	27	O-RING	2
11	COLLAR	1	28	O-RING	1
12	SPACER	6	29	O-RING	1
14	DISTANCE PIECE	3	30	O-RING	1
15	COUPLING	1	31	FLOATING SEAL	1
16	SHAFT	1	33	PLUG	2
17	PIN	24	37	EXPANDER	1

2.2 FUNCTIONAL EXPLANATION

2.2.1 REDUCTION UNIT

(1) Function

The reduction unit consists of a spur gear device (hereinunder called No.1 reduction section) and a differential gear device (hereinunder called No.2 reduction section). The reduction unit reduces the high speed rotary motion of the hydraulic motor and converts it to low speed, large torque to obtain hub (1) (case) rotation.

(2) Functional Explanation

1) No. 1 Reduction Unit

The rotary motion of the hydraulic motor shaft is transmitted to input gear (6) linked to the spline of shaft (102).

On that occasion, spur gear (7) is meshed with the input gear and rotates at reduced speed.

The reduction ratio of the No. 1 reduction unit is as follows :

$$il = -\frac{ZS}{Zi}$$

where i = Reduction ration of the No. 1 reduction unit

Zi = Number of gear teeth of the input gear

Zs = Number of gear teeth of the spur gear

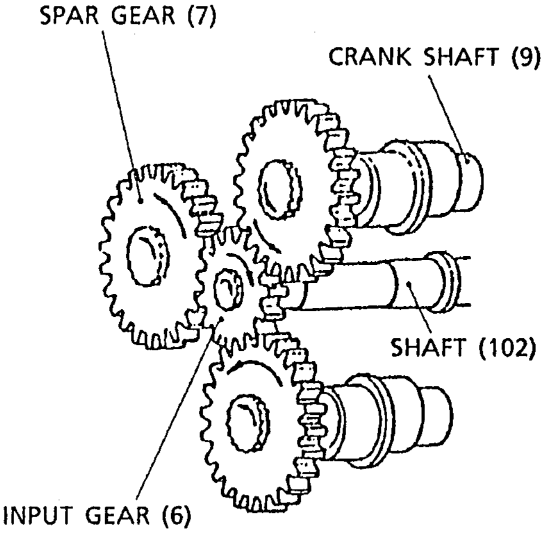


Fig. 5

2) No. 2 Reduction Unit

a) Each of the spur gears (three) is splined to each crankshaft (9) which becomes inputs to the No.1 and No.2 reduction units.

If crankshaft (9) rotates, the eccentric parts A and B of the crankshaft rotates while making eccentric motion (revolving motion).

The eccentric bodies A and B and the needle bearings fixed in the eccentric bodies cause the RV gears "A" (4) and "B" (5) to transmit only the eccentric motion out of the eccentric motion and the revolution of the eccentric bodies A and B.

Thus the RV gears A and B make an eccentric motion in the same direction and at the same revolution that the spur gears and the crankshafts do.

b) If the RV gears A and B make eccentric motion, the tooth surface ZR of the RV gear A or RV gear B meshes with ZP

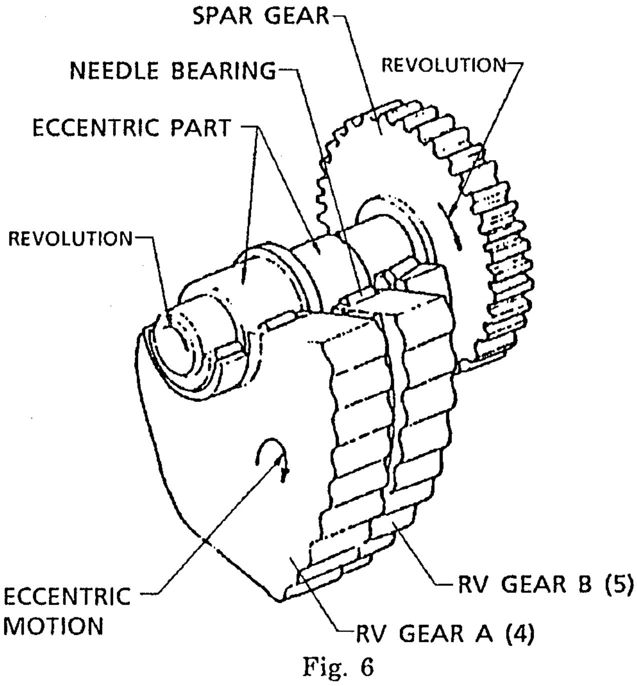


Fig. 6

pieces of pins (17) and ratatably changes the meshing points in sequence.

When the RV gear A or the RV gear B makes one complete eccentric motion, the pins revolves by the difference between the number of teeth and the number of pins ZP $[(ZP-ZR)/ZP]$ in the same direction as the eccentric motion.

The rotation of the pins is transmitted to the hub and becomes an input revolution of the reduction unit.

As the result, the reduction ratio of the No. 2 reduction unit is as follows:

$$i2 = -\frac{(ZP-ZR)}{ZP}$$

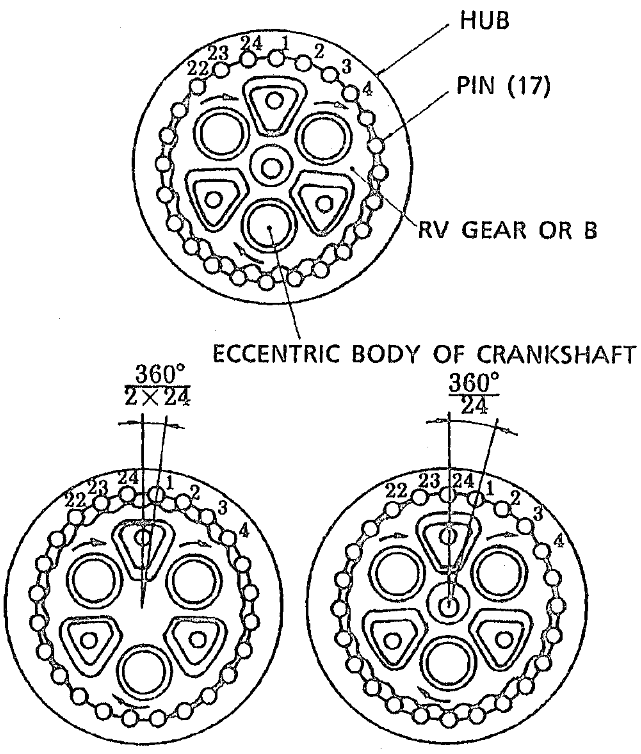
Where i2 = Reduction ratio of the No. 2 reduction unit
ZR = Number of RV gears A and B
ZP = Number of pins

Thus an output revolution of the hydraulic motor shaft when it makes a complete turn is as follows:

$$i = i1 \times i2$$

i1 = Reduction ratio of the No. 1 reduction unit
i2 = Reduction ratio of the No. 2 reduction unit

$$i = -\frac{ZS}{Zi} \times \frac{(ZP-ZR)}{ZP}$$



WHEN TURNED HALF (180°) WHEN TURNED ON REVOLUTION

Fig. 7

2.2.2 HYDRAULIC MOTOR (BRAKE VALVE AND HI-LOW CHANGEOVER MECHANISM)

(1) Function

1) Hydraulic Motor

The hydraulic motor is what is called a swash plate type axial piston motor that converts the force of the hydraulic pressure delivered by the pump to rotary motion.

2) Brake Valve

a) It smoothly brakes the GM motor to a stop by controlling the inertial force produced as the GM motor attempts to turn the moment it stops.

b) It serves as a check valve that prevents cavitation of the hydraulic motor.

c) It serves as a surge cut valve controlling the braking pressure of the hydraulic motor and also acts as an anti-cavitation valve that prevents cavitation.

3) High-low changeover mechanism

The action of the changeover valve and the control piston changes the tilting angle of the swash plate to two steps ; high-speed, low torque rotation and low-speed, high torque rotation.

4) Parking brake

The parking brake prevents, by its friction type braking mechanism, racing and slippage of the excavator on a slope or in a parked or stopped condition. The parking brake is constructed integral with the hydraulic motor.

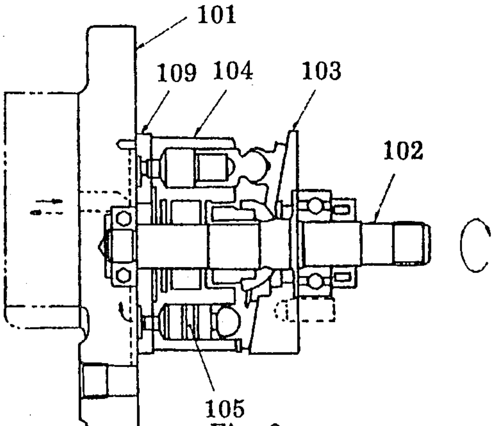


Fig. 8

(2) Functional Description

1) Hydraulic Motor

The hydraulic pressure delivered by the pump enters rear flange (101) of the GM motor and is admitted into cylinder block (104) by way of the brake mechanism and timing plate (109). It is so designed that the hydraulic pressure is introduced only to one side of a line Y1 – Y2 connecting the top and bottom dead points of the process of piston (105). The hydraulic pressure entering one side of the inside of cylinder block (104) pushes each of pistons (105) (four or five pcs) and produces a force ($F1kgf = Pkgf/cm^2 \times Acm^2$). This force which acts upon (swash) plate (103) is divided into components (F2,F3) as the (swash) plate (103) is fixed at an angle (a) with regard to the axis line of drive shaft (102). Out of the components, the radial component (F3) produces torques ($T = F3 \times ri$) with regard to the line Y1 – Y2.

The resultant of these torques($T = \Sigma\ (F3 \times ri)$) turns the cylinder block (104) via pistons (105). The cylinder block (104) which is connected with the spline of drive shaft (102) turns drive shaft (102), thereby transmitting torque.

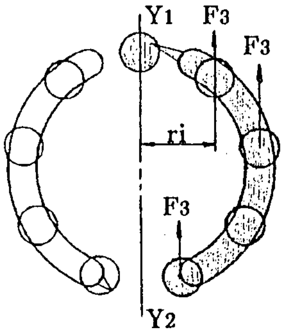
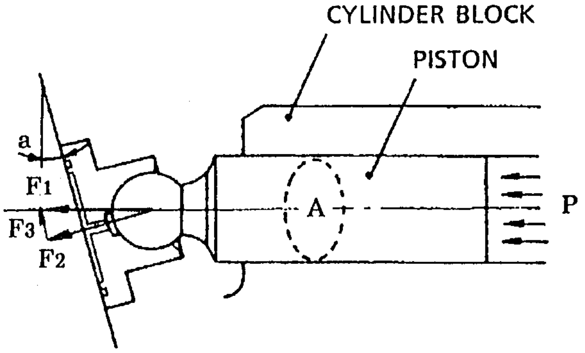


Fig. 9



Fig, 10

2) Brake valve

a) During operation (brake released)

If pressurized oil is supplied to port (A), it opens valve (127), enters suction port (C) of the hydraulic motor and attempts to turn the hydraulic motor.

At the same time the pressurized oil enters chamber (b) past path (a) through the orifice, acts on the end face of the spool and builts up power. Then the action of spring (128) moves the spool in neutral leftwards.

When the spool slides, a clearance (path) is formed between the groove of the spool and the rear flange.

This path connects port (D) of the return path of the hydraulic motor with another port (B) and brings the return oil to the tank so as to rotate the hydraulic motor.

The transfer of spool (123) causes the pressurized oil to enter port (P) and port (S). The pressurized oil which has entered port (P) actuates piston (112) of the parking brake to release the parking brake. (For further details, see Parking Brake section.

In the meantime, the pressure which has entered port (S) enters chamber (t), presses stopper (157) against the inner surface of body (155) so as to prevent spool (156) from moving, thereby preventing port (C) of the hydraulic motor from being connected during operation. If pressurized oil is supplied from port (B) (the suction and the return sides of the hydraulic motor), the movements of spool (123) and valve (127) are reversed so that the hydraulic motor is reversed accordingly.

b) During overrunning

A condition in which the hydraulic motor rotates faster than the oil delivery rate of the hydraulic pump as the travel speed of the excavator gets high on a steep slope is called overrun.

Since hydraulic pressure goes away the same way as when the excavator is stopped, the brake valve operates the same way as at stop : It restricts the return path of the hydraulic motor and creates back pressure. This decelerates the hydraulic motor attempting to rotate by inertial force so that the revolution of the hydraulic motor matches the feed rate of the pump.

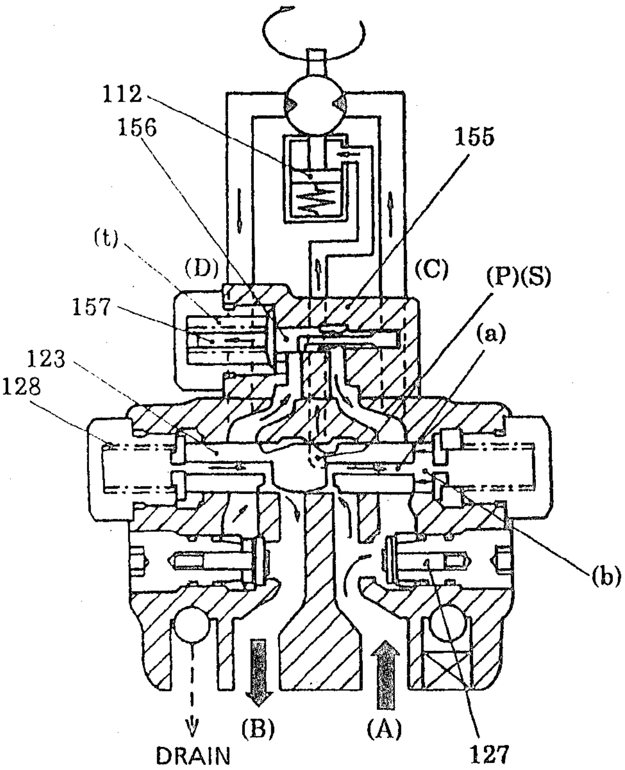


Fig. 11

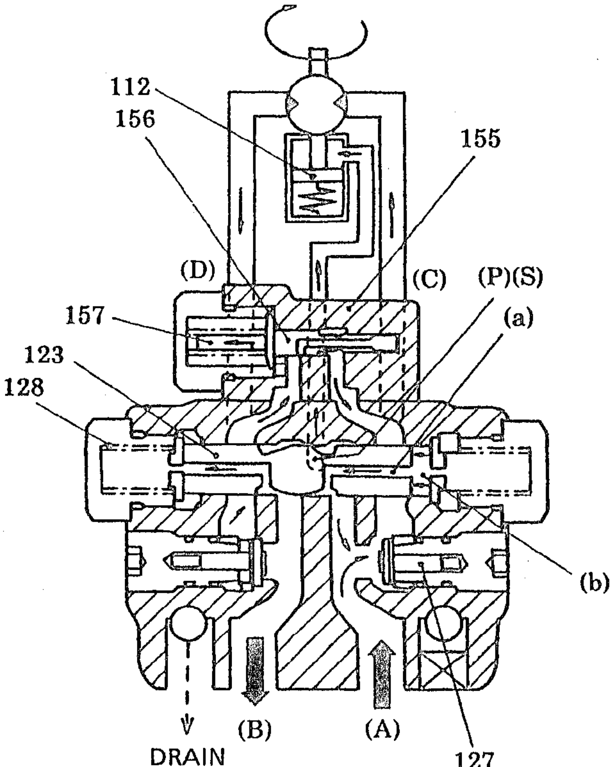


Fig. 12

c) At stop or stall (brake action)

If pressurized oil fed from port (A) is stopped during running, hydraulic force pressing the spool is lost. Then spool (123) sliding leftwards tries to return to neutral position via stopper (125) by the action of spring (128). On that occasion, the oil in chamber (b) passes through path (a) in the spool and tries to go out to port (A). However, back pressure is produced by the restricting the effect of path (a) to control the returning speed of the spool. At the same time, the hydraulic motor attempts to rotate by its inertia even after the motor is stopped. As the result, the returned oil from the hydraulic motor passes through the clearance (path) between the spool groove and the rear flange past port (D) and attempts to go back to port (B). When the spool returns to neutral completely, the return path of the hydraulic motor is shut off completely by the spool to stop the hydraulic motor. In actual operation, the brake valve chokes the return path of the hydraulic motor, depending upon the sliding speed control of the spool and the groove shape of the spool and creates back pressure that smoothly stops the hydraulic motor attempting to rotate it by inertial force. Since inertial force tries to rotate the hydraulic motor, the hydraulic motor converts its motor action to pumping action that sucks oil. However, since hy-draulic pressure is shut off, oil is not sup-plied which brings about cavitation of the hydraulic motor, having adverse effect on the hydraulic motor. At the same time, since the path is closed by spool (123), a phenomenon of the returned oil from the hydraulic motor contained at port (D) is produced which raises the pressure. This pressure moves spool (156) leftwards and short-circuits port (D) to port (C).

This prevents rise in the pressure and occurrence of cavitation.

(Surge cut valve function and anti-cavitation valve function)

Valve (127) operates by minimal negative pressure, opens the oil path between the circuit at port (A) and port (C) at the suction of the motor and prevents cavitation of the hydraulic motor.

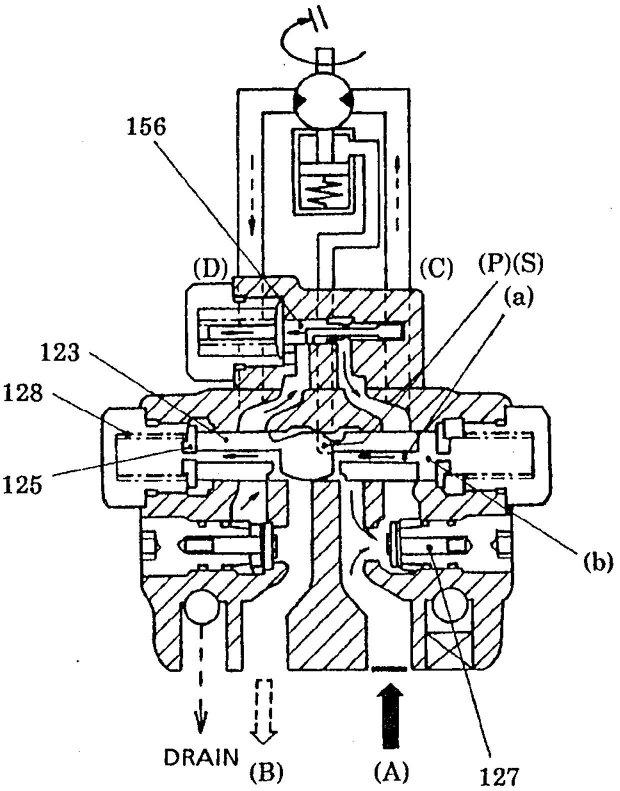


Fig. 13

3) Parking Brake

a) At Running

If pressurized oil is supplied from the brake valve, the spool (123) of the brake valve in the hydraulic motor operates, opens the path to the parking brake and causes the pressure to be introduced to cylinder chamber (a) that consists of spindle (2) and piston (112) in the reduction unit.

When oil pressure arrives at 9kgf/cm^2 (128psi), it overcomes spring (113) and moves piston (112) to rear flange (101). The movement of piston (112) deprives the piston (112) of the pressing force against companion plate (116) and friction plate (115). This frees friction plate (115) fixed in cylinder block (104) of the hydraulic motor and releases the braking force to cylinder block (104).

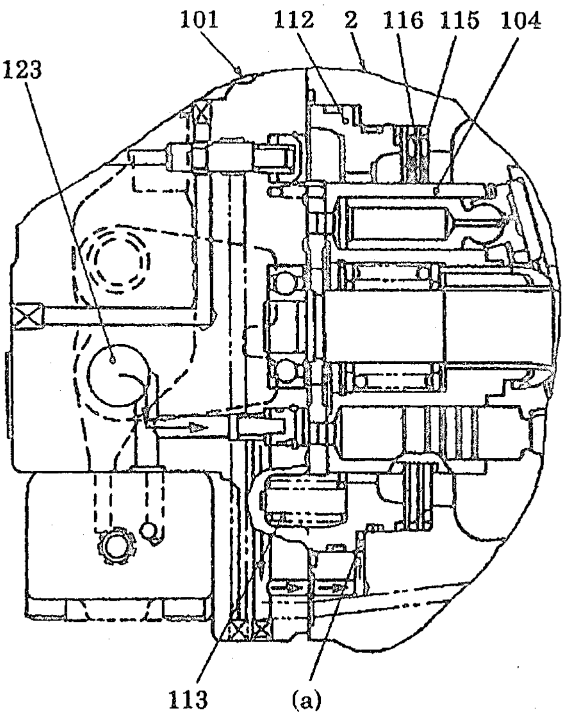


Fig. 14

b) At Stop

If the pressurized oil from the brake valve is shut off and the pressure in cylinder chamber (a) falls below 9kgf/cm^2 (128psi), piston (112) tries to return by the action of spring (113). Pressing of piston (112) causes companion plate (116) and friction plate (115) in free condition to be pressed against spindle (2) in the reduction unit. Frictional force created by this pressing stops the rotation of cylinder block (104) and gives the hydraulic motor shaft a braking torque (8.4kgf·m (61ft·lbs)). The brake operates smoothly as oil flow is controlled by an appropriate oil path.

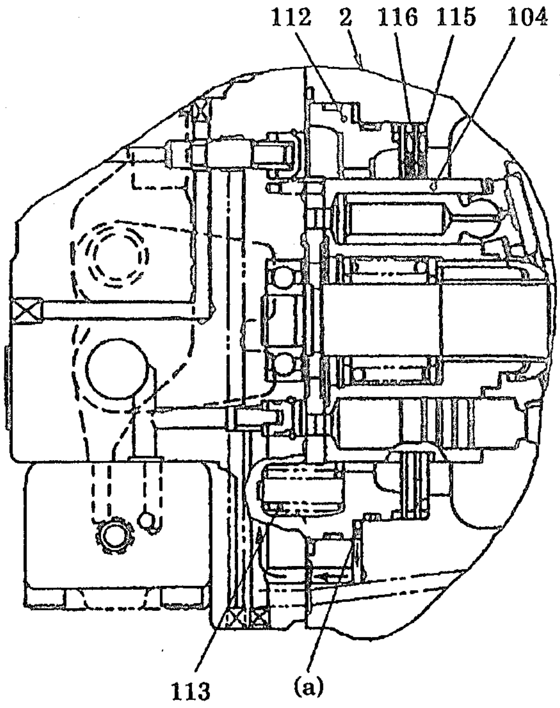


Fig. 15

4)High-low changeover mechanism

a) Where pilot pressure (a pressure less than 10kgf·cm^2 (142psi)) is not fed from port (A) at low speed (a pilot pressure less than 10kgf·cm^2 (142psi)), valve (163) is pressed leftwards by the action of spring (166). This shuts off the oil pressure of feed port (B) and the oil in chamber (C) is released into the motor casing via the valve. Therefore, swash plate (103) takes the maximum tilting angle θ1 which maximizes the piston stroke capacity of the hydraulic motor to rotate the motor at low speed.

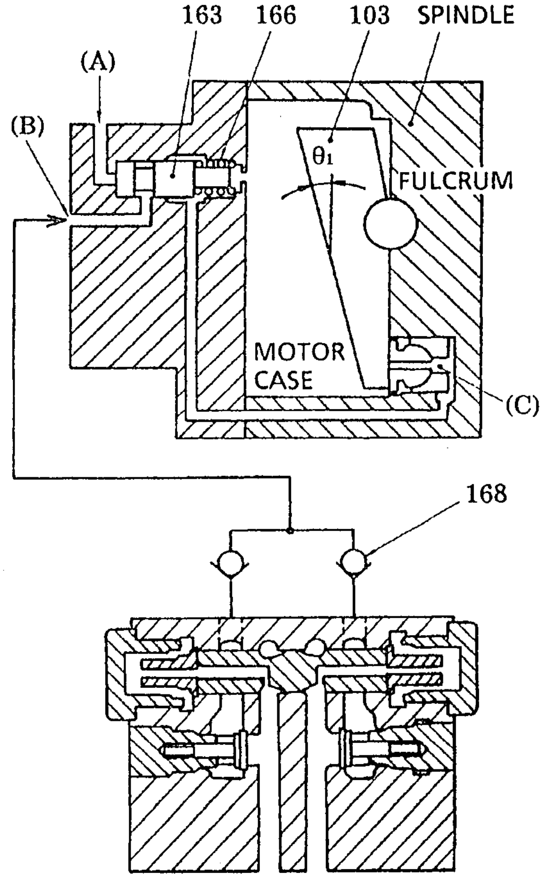


Fig. 16

b) Where pilot pressure is supplied from port (A) (a pressure over 20kgf·cm^2 (284psi)) at high speed (a pilot pressure over 20kgf·cm^2 (284psi)), it overcomes the action of spring (166) and presses valve (163) rightwards. The result is that the pressurized oil of feed port (B) is admitted to chamber (C) via valve (163). Piston (161) then pushes up swash plate (103) till it strikes surface (b) of spindle (2) and holds it in that position.

On that occasion, swash plate (103) takes the minimum tilting angle θ2 and minimizes the piston stroke capacity of the hydraulic motor to rotate the motor at high speed.

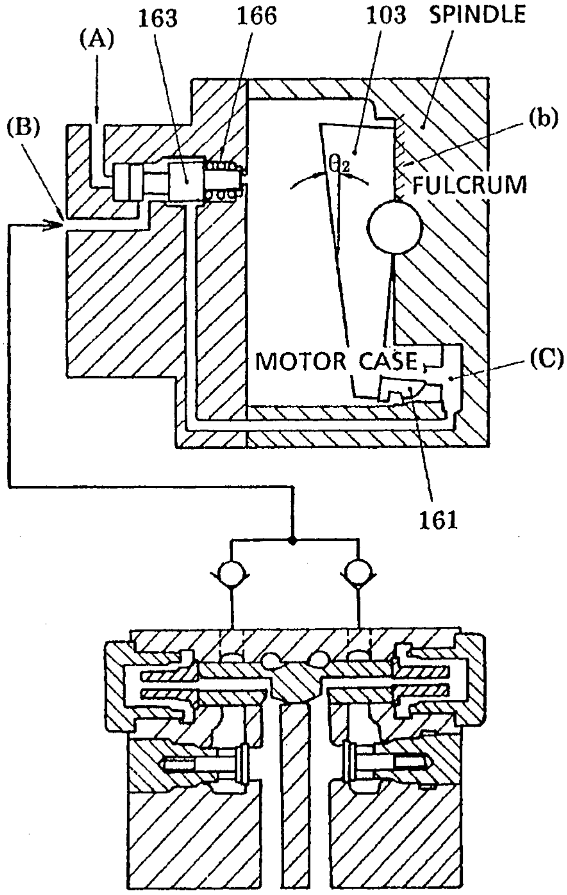


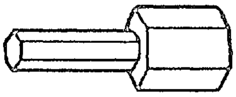
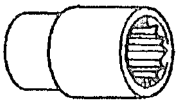
Fig. 17

3. DISASSEMBLY AND ASSEMBLY

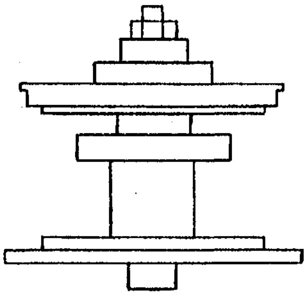
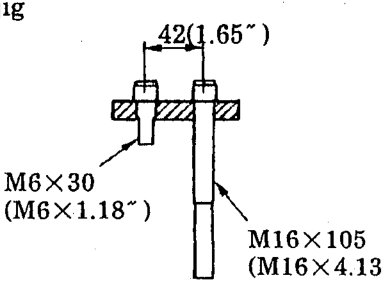
3.1 TOOLS AND JIGS

3.1.1 TOOLS

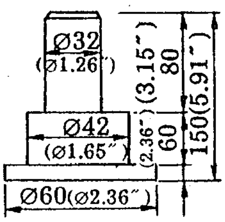
Table 2

Symbol	Name	Model · Size	Q' ty
a	Allen key wrench	6 (For M 8) 8 (For M10) 10 (For M12)	1 1 1
b	Socket wrench (Tumbler type)		1
c	Torque wrench (I) (II)	18kg · m (130 ft · lbs) or so 56kg · m (400ft · lbs) or so	1 1
d	Adapter for torque wrench	8. Wrench 10. Wrench 	1 1
		27. Socket 36. Socket 	1 1
e	Extension bar	150mm (5.91″) (12.7×19.05 (0.5″×0.75″))	1
f	Hammer	Hammer #1 size or so Plastic hammer L=300mm (11.8″)or so	1 1
g	Flat-blade screwdriver (long)	150mm (5.91″) or so	2
h	Snap ring pliers	For shaft For hole and groove	1 1
i	Spanner	Reinforcement plate 36 (For M24)	1
j	Lifting tool	Lifting load : 300kg (660 lbs) or over Eye bolt (For M16) Eye bolt (For PT1/2) Chain string (wire sling)	1 set (2) (2) (1)
k	Work bench for press	Pressing capacity : 200kg (440 lbs) or over	1 set
l	Compressed air	For 3~5 kg/cm² (43~71 psi) Nozzle for above	1 set
m	Thickness gauge	0.04~0.3mm (0.0016″~0.0118″)	1 set
※	Micro meter	0~25mm (0~0.98″) min. scale : 0.01(0.0004″)	1
n	Heating bath	Heating capacity : 100°C (212°F) or over Volume : 500×500×500 (20″ ×20″ ×20″) or over	1 set
o	Plastic bag		2
p	Seal tape		1 roll
q	Depth micrometer	Measuring range :30mm(1.18″)or so, min. scale : 0.01(0.0004″)	1
r	Leather gloves		1 pair

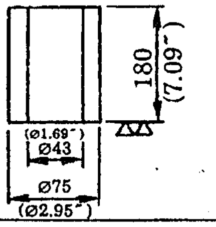
3.1.2 JIGS

<table>
<tr><th>No</th><th>Nomenclature and major dimension</th><th>Q'ty</th></tr>
<tr><td>1</td><td>Clearance measuring jig
</td><td>1</td></tr>
<tr><td>2</td><td>Fixing jig


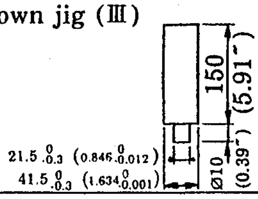
42(1.65")
M6×30
(M6×1.18")
M16×105
(M16×4.13

</td><td>2</td></tr>
<tr><td>3</td><td>Holding-down jig (I)


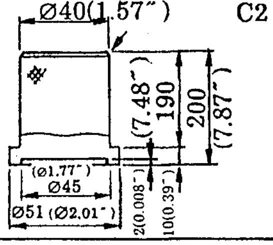
Ø32
(Ø1.26")
Ø42
(Ø1.65")
Ø60(Ø2.36")
(2.36")
60
(3.15")
80
150(5.91")

</td><td>1</td></tr>
<tr><td>4</td><td>Holding-down jig (II)


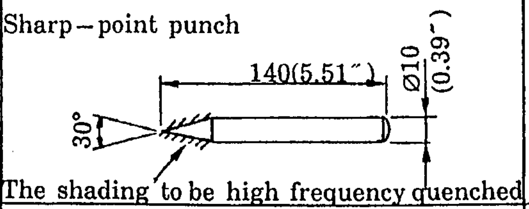
180
(7.09")
(Ø1.69")
Ø43
Ø75
(Ø2.95")

</td><td>1</td></tr>
<tr><td>5</td><td>Holding-down jig (Ⅲ)


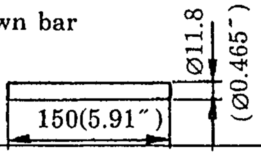
150
(5.91")
21.5 $^{0}_{-0.3}$ (0.846 $^{0}_{-0.012}$)
41.5 $^{0}_{-0.3}$ (1.634 $^{0}_{-0.001}$)
Ø10
(0.39")

</td><td>1</td></tr>
<tr><td>6</td><td>Holding-down jig (Ⅳ)


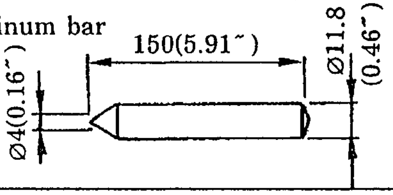
Ø40(1.57")
C2
(7.48")
190
200
(7.87")
(Ø1.77")
Ø45
Ø51 (Ø2.01")
2(0.008")
10(0.39")

</td><td>1</td></tr>
<tr><td>7</td><td>Sharp-point punch


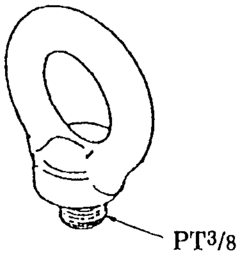
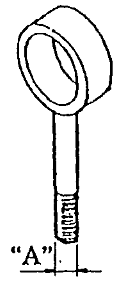
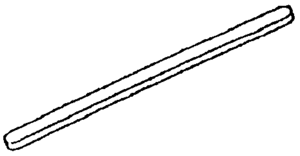
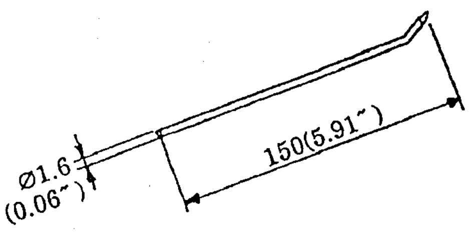
140(5.51")
Ø10
(0.39")
30°
The shading to be high frequency quenched

</td><td>1</td></tr>
<tr><td>8</td><td>Holding-down bar


Ø11.8
(Ø0.465")
150(5.91")

</td><td>1</td></tr>
<tr><td>9</td><td>Aluminum bar


150(5.91")
Ø11.8
(0.46")
Ø4(0.16")

</td><td>1</td></tr>
<tr><td>10</td><td>Eye bolt for PT
 </td><td>2</td></tr>
<tr><td>11</td><td>Long eye bolt
<table><tr><th>Service</th><th>"A"</th></tr><tr><td>Hub</td><td>M14</td></tr><tr><td>Spindle</td><td>M16</td></tr><tr><td>Drive motor</td><td>M14</td></tr></table> </td><td>2</td></tr>
<tr><td>12</td><td>Spatula
</td><td>1</td></tr>
<tr><td>13</td><td>Scriber


Ø1.6
(0.06")
150(5.91")

</td><td>1</td></tr>
</table>

3.2 GENERAL PRECAUTIONS TO BE EXERCISED AT DISASSEMBLY

1) Because hydraulic components are precision finished in general, handle them in a clean place with little dust. Use clean tools, cleaning oil and dry compressed air. Avoid using rag and paper.
2) Plug each of the ports of the travel motor dismantled from the excavator body and clean all dirt and oil completely from outside the motor before proceeding to disassembly operation.
3) Leave matching marks on the mating surface of parts, as required. Arrange dismantled parts in order during operation, exercising care so as not to damage parts and not to lose them.
4) Sealing parts, such as, O rings and backup rings can not be reused once removed.
   Check prearranged parts against A List of Seal Kits to prepare for reassembly.
5) Some parts can not be supplied singly and can only be supplied in subassemblies. Prepare such parts in advance, referring to parts catalogues.

☞ The numbers in parentheses after part names represent the structure drawings (Fig. 2 and 3).

3.3 CLASSIFICATION OF DISASSEMBLY ITEMS

The travel motor ass'y consists of a hydraulic motor, a reduction unit, a brake valve and a parking brake all put together in one piece.

Disassembly operation consists roughly of the following : Choose necessary items for each of the hydraulic motor, the reduction unit, the brake valve and the parking brake, determine disassembly procedures and perform disassembly according to the procedures.

☞ Avoid disassembling unnecessary portions.

(1) Preparation before proceeding to disassembly
  1) Cleaning
  2) Installing the travel motor ass'y onto a work bench
  3) Draining out oil

(2) Dismantling cover (8) of the reduction unit
(3) Separating input gear (6)
(4) Removing rear flange (101)
(5) Dismantling rear flange fittings
(6) Dismantling the brake valve
(7) Separating the surge cut valve
(8) Taking out pilot valve (163) in the rear flange
(9) Dismantling plug (152)
(10) Separating parking brake valve (119)
(11) Disassembling the parking brake
(12) Separating the hydraulic motor section
(13) Removing spring (114) in the cylinder block
(14) Drawing out drive shaft (102)
(15) Dismantling spur gear (7)
(16) Dismantling hold flange (3)
(17) Removing spindle (2)
(18) Removing the RV gear ass'y
(19) Separating bearing (21) and collar (11)
(20) Disassembling spindle (2) fittings
(21) Disassembling hole flange (3) fittings
(22) Rough cleaning of parts
(23) Finish cleaning

3.4 DISASSEMBLING PROCEDURE

(1) Preparation before Disassembly

1) Cleaning

Fit eye bolts to the tapped holes on spindle (2) to which the sprocket is attached, lift up the travel motor ass'y and clean the outer circumference.

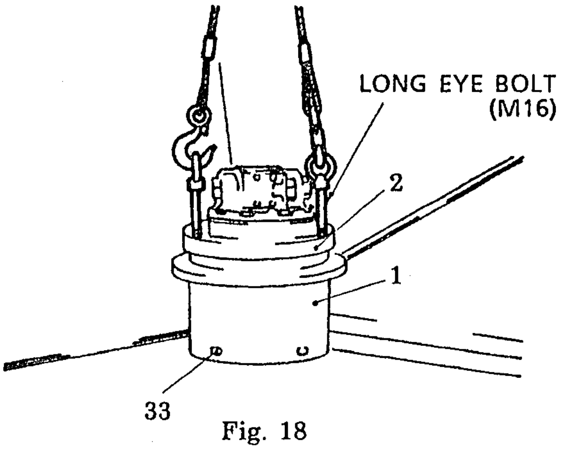


Fig. 18

☞ Clean the gap between hub (1) and spindle (2) (to which floating seal (31) is to be fixed) with particular care as sand and soil may stay there.

2) Attaching the travel motor ass'y onto a work bench

Install the travel motor ass'y on a suitable work bench with cover (8) facing down and fix it firmly.

A rotary type work bench is convenient for this purpose.

3) Draining out oil

Remove two socket head plugs (33) and drain oil out.

☞ Receive drained oil in a clean container, check for contamination and metallic particles and take proper action as required.

(2) Dismantling cover of the reduction unit

1) Mark on the matching surface between hub (1) and cover (8), using marker paint.

2) Find the mating part of ring (18), and punch at a point of the outside of the hub, approximately 20mm (0.79in) inward from the tip of ring (18) for drilling purpose.

3) Drill through a 2mm (0.08in) hole from the outside of hub (1) toward ring (18).

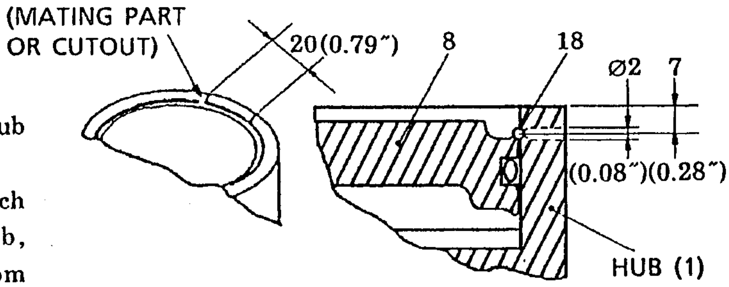


Fig. 19

☞ ● Drill toward the center of the ring wire material till the rise ring rises over the cover by the pressure of the drill.

● Wipe off all chips resulting from drilling so they may not adhere to disassembled parts.

4) Put a steel rod into the hole and push ring (18) out of the ring groove of hub (1).

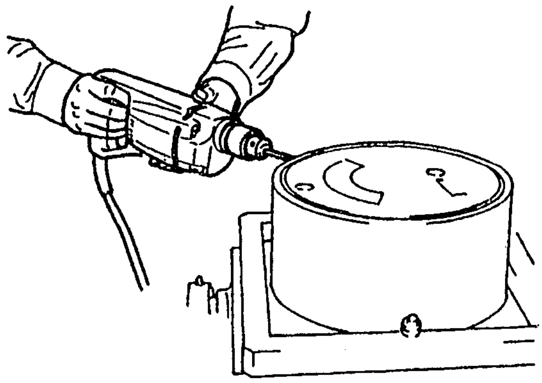


Fig. 20

5) Fix 3/8 PT eye bolts to the two tapped holes of cover (8) (to which socket head plugs (33) and fixed usually), lift the body and remove cover (8).

☞ If cover (8) is hard to remove because of the resistance of O ring (29), lightly tap the outer circumference of cover (8) evenly all round, using a plastic mallet to give it vibrations.

6) After removing cover (8), take off O ring (29).

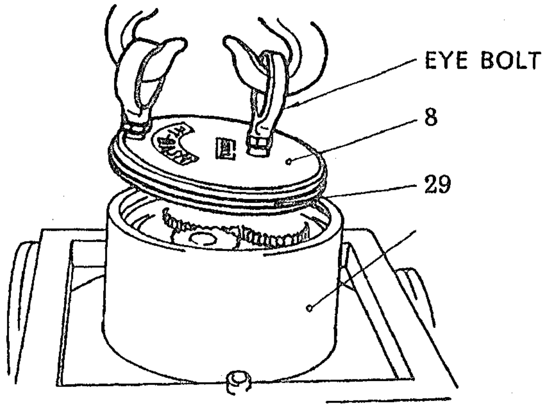


Fig. 21

(3) Separating input gear (6)
1) Separate snap ring (24) from shaft (16) and draw input gear (6) out of shaft (16).
2) Then, draw shaft (16) out of coupling (15) and remove ball (26) fixed to the tip of shaft (16).
3) Separate coupling (15) from drive shaft (102).

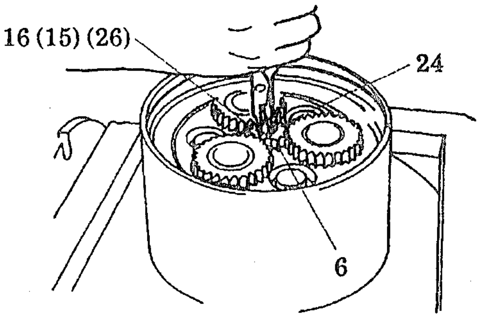


Fig. 22

(4) Dismantling rear flange (101)
1) Turn over the travel motor ass'y upside down and loosen two plugs (124) and a plug (160) to an extent that they can be turned by hand.
2) Loosen two plugs (126) the same way.
3) Remove four socket head capscrews (170) and separate surge cut valve (155) from flange (101).

☞ Where you do not have to disassemble the brake valve and the surge valve that are attached to rear flange (101), leave plugs (124), (160) and (126) intact.

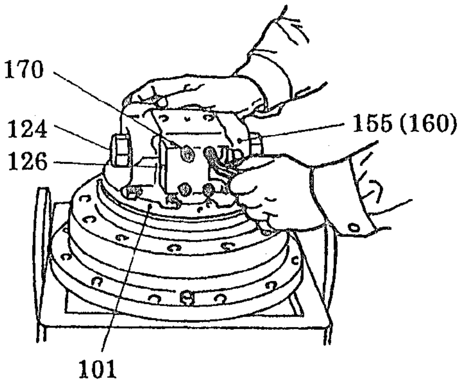


Fig. 23

4) Remove eight socket head capscrews (143) and separate rear flange (101) from spindle (2).

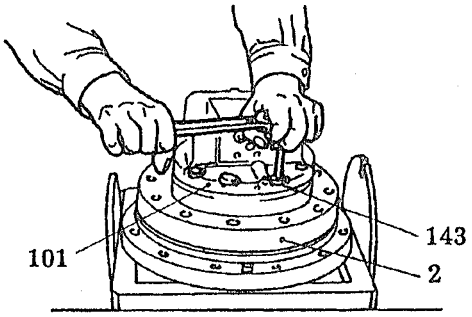


Fig. 24

⚠ When removing rear flange (101), pull it up straight and gently by both hands. Forced prying or striking it may cause timing plate (109) to fall and damage it.

5) Separate spring (113) from rear flange (101).

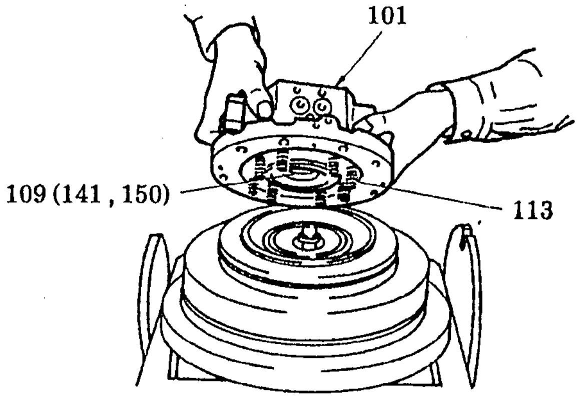


Fig. 25

6) Draw two parallel pins (142) out of spindle (2).
7) Take off O rings (27) and (30).

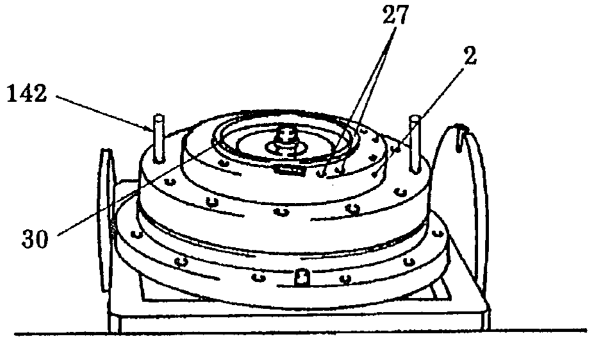


Fig. 26

(5) Dismantling the rear flange fittings
1) Place rear flange (101) on a work bench, with the matching surface for spindle (2) facing up.
2) Separate timing plate (109) from rear flange (101).

⚠ If it is hand to remove the fittings as matching surfaces are in close contact with each other, insert a spatula into the as-cast groove in the matching surface on the rear flange side and lift up the timing plate a little. Note that inserting a sharp tool such as a screw-driver into the matching surface may cause leakage.

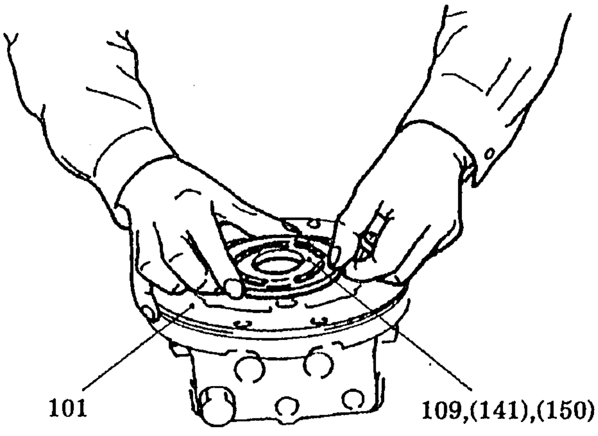


Fig. 27

3) Draw two parallel pins (141) out of rear flange (101).
4) Dismantle bearing (150) from rear flange (101).

(6) Disassembling the brake valve parts

1) Remove two plugs (124) of rear flange (101) that were loosened beforehand.
2) Take out spring retainer (125) and RH and LH springs (128, 129) from rear flange (101).
3) Take out spool (123) from rear flange (101).

☞ To take out spool (123), place your hand on one part of the plug port of flange (101) and tilt it down. Then spool (123) falls down. Hold the tip and take it out.

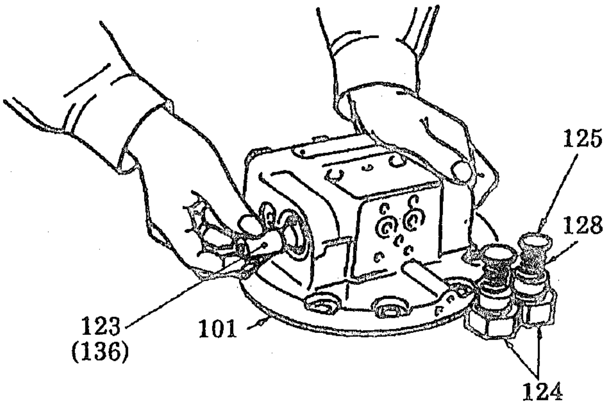


Fig. 28

4) Take out two plugs (126) from rear flange (101).
5) Take out spring (130) and RH and LH anti-cavitation valves (127) from rear flange (101).
6) Take off O ring (136) from each of plugs (124).
7) Take off O ring (137) from each of plugs (126).

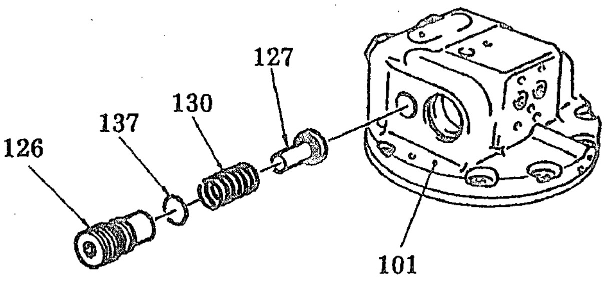


Fig. 29

(7) Disassembling the surge cut valve

1) Take out plug (160) from body (155).
2) Draw out springs (158, 159) and stopper (157) from body (155).
3) Take out surge cut spool (156) from body (155).

⚠ Body (155) and surge cut spool (156) have a close fit. Therefore, in case any one of them is faulty, always replace them as a body kit that consists of a body and a surge cut valve.

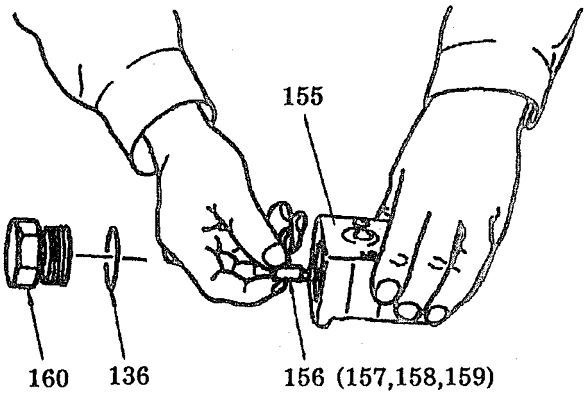


Fig. 30

☞ When taking out surge cut spool (156), use particular care so as not to score the sliding part

4) Separate O ring (136) from plug (160).
5) Remove O rings (138, 140) from the O ring grooves in mounting surface of body (155) and rear flange (101).

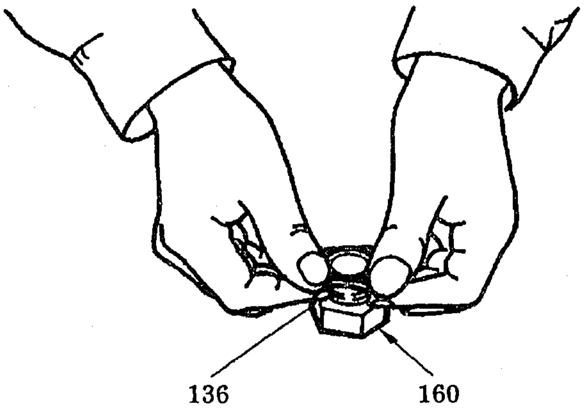


Fig. 31

(8) Taking out pilot valve (163) from the rear flange
1) Place a sharp-point punch against the notch of ring (165) and hammer the punch till ring (165) comes out.
2) If you turn over rear flange (101) and hold it up, you can draw out stopper (164), spring (166) and pilot valve (163) from inside the rear flange.

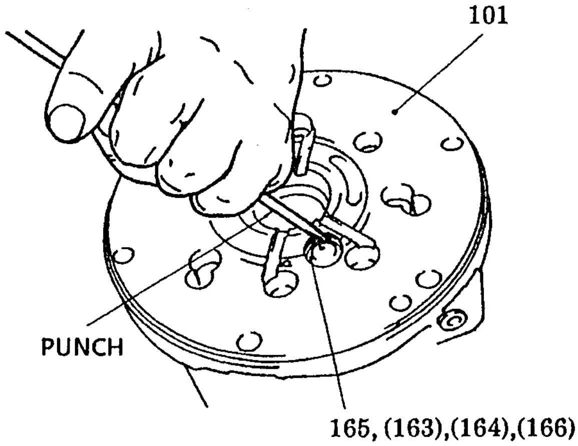


Fig. 32

☞ ● Do not remove ring (165) except when removing pilot valve (163).
● If ring (165) is taken out, the hole area will be scored. Therefore, recondition the area after removal.
● Where the inside parts can not be drawn out even if the hole is directed down, apply compressed air through the 2-speed changeover port gently.
● Do not reuse removed ring (165).

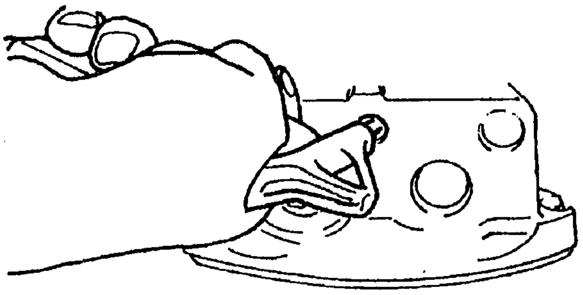


Fig. 33

(9) Removing plug (152)
1) In case the travel motor gets out of order because of dirt inclusion, remove plug (152), draw out ball (168) and clean the oil inlet.

☞ ● Never remove the plug except when necessary.
● Take care when removing the plug as the ball tends to fall down.

(10) Dismantling parking brake valve (119)

1) Place rear flange (101) on a work bench with its matching surface up.
2) Place a scriber to the notch of ring (122), holding down valve seat (118) with a steel rod and remove rear flange (101).

☞ ◉ Do not remove ring (122) except when valve (119) must be replaced.
◉ Do not forget to recondition the scoring of the hole resulting from removing ring (122).

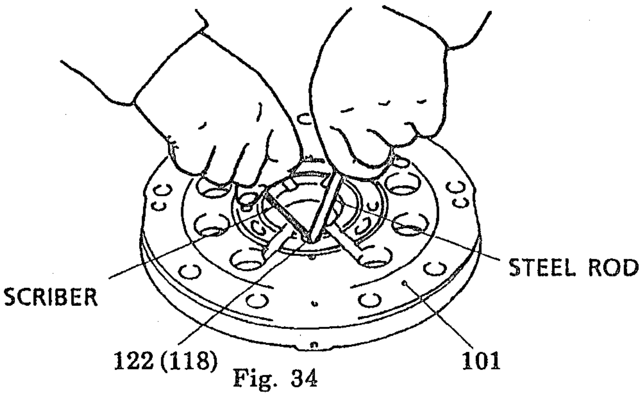


Fig. 34

3) Plug up the hole in valve seat (118), blow in jet air through the oil path on the mounting surface of the surge cut valve and then take out valve seat (118).
4) Valve (119) and spring (120) can be taken out if you direct the hole down and shake rear flange (101) up and down lightly.
5) Draw out O ring (133) from valve seat (118).

☞ Do not reuse once removed ring (122).

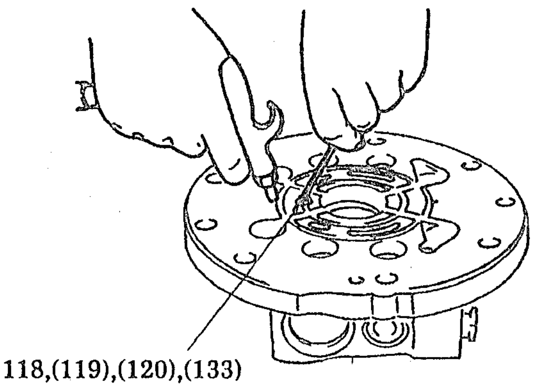


Fig. 35

(11) Disassembling the parking brake

1) Blow in compressed air through the path (bore side) of the parking brake pipe of spindle (2) and draw out piston (112) slowly from spindle (2).

⚠ Note that if you blow in compressed air too quickly, piston (112) will pop up which is very dangerous. Use such safety measures as a protection cover over piston (112).

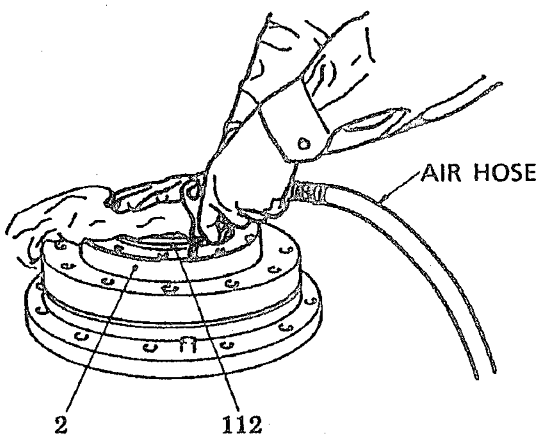


Fig. 36

2) Remove O rings (135, 139) and backup rings (147, 148) from piston (112).

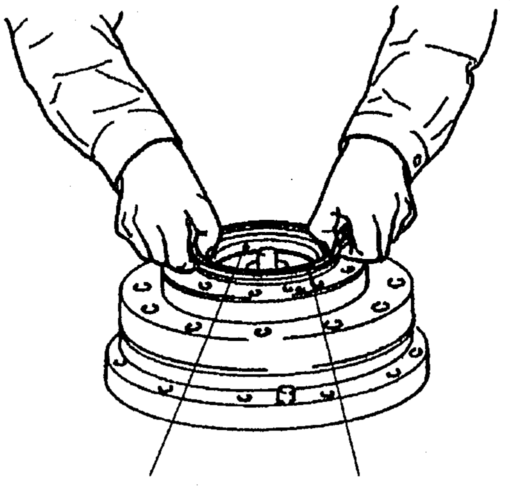


Fig. 37

(12) Disassembling the hydraulic motor section

1) Replace the travel motor body on the work bench so its flange surface stands upright and then let the inside oil out.

☞ If the travel motor is tilted, oil will be spilt. Therefore prepare an oil container under the mounting stand.

2) Hold cylinder block (104) by hand and draw it out of drive shaft (102). On that occasion, plate (friction plate) (115) and plate (companion plate) come off together with cylinder block (104).

☞ Before drawing out cylinder block (104), turn it clockwise and counterclockwise several times and separate shoe (106) from swash plate (103). Note that if you draw out cylinder block (104) jerkily, piston (105) and shoe (106) which should be taken out with cylinder block (104) remain on swash plate (103) and drop into spindle (2).

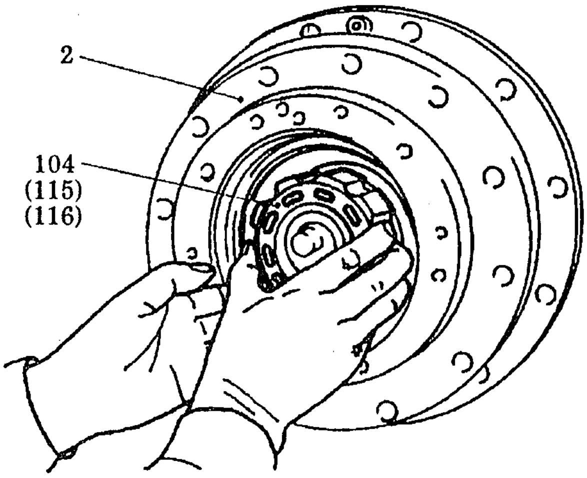


Fig. 38

3) Remove plate (friction plate) (115) and plate (companion plate) taken out with cylinder block (104).

4) Draw out cylinder block (104) that consists of pistons (105) and shoes (106).

☞ ◎ Hold the outer circumference of retainer plate (107) by both hands and draw out pistons (105) and shoes (106) together.

◎ Piston (105) and shoe (106) are reduced at the spherical part of the piston and make up one piece. In case either of them needs replacement, replace both with the piston ass'y (piston kit) consisting of nine pistons.

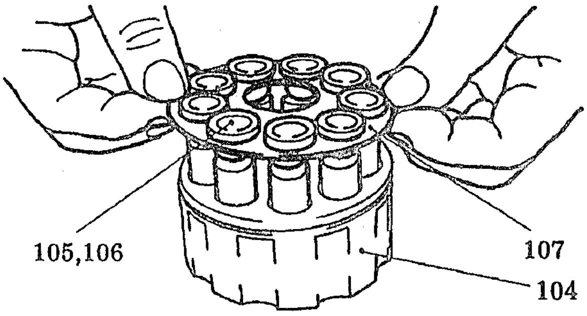


Fig. 39

5) Draw out the piston ass'y [piston (105) and shoe (106)] from retainer plate (107).

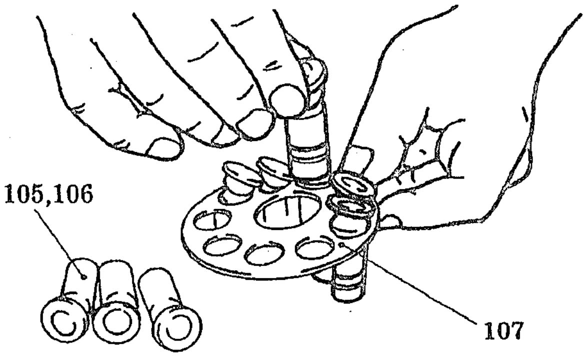


Fig. 40

6) Take out thrust ball (108) from cylinder block (104).

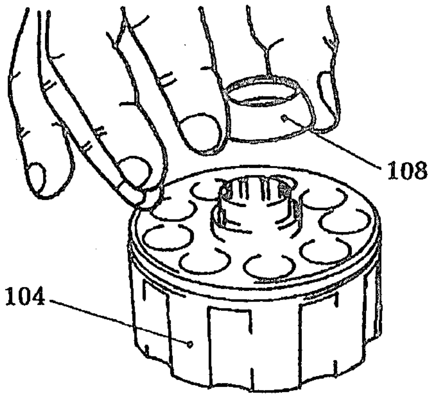


Fig. 41

7) Take out three needle rollers (151) from cylinder block (104).

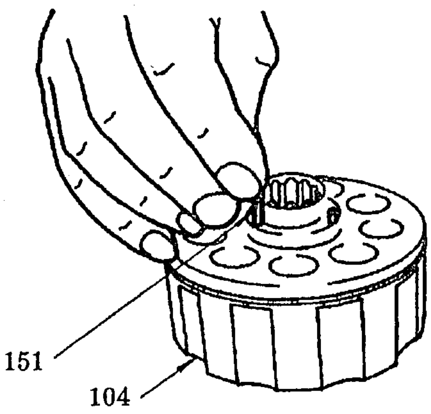


Fig. 42

(13) Removing spring (114) from inside the cylinder block

1) Mount cylinder block (104) on the press bench, push washer (110) in by means of holding-down metal (I) and separate snap ring (145) from the snap ring groove, using snap ring pliers.

☞ • Align holding-down metal (I) with washer (110) completely. Cover the cylinder block with a plastic sheet to prevent the inner surface of cylinder block (104) from being damaged by contact and also to prevent the surface from being scored.

• Do not disassemble the cylinder block except when snap rings are replaced.

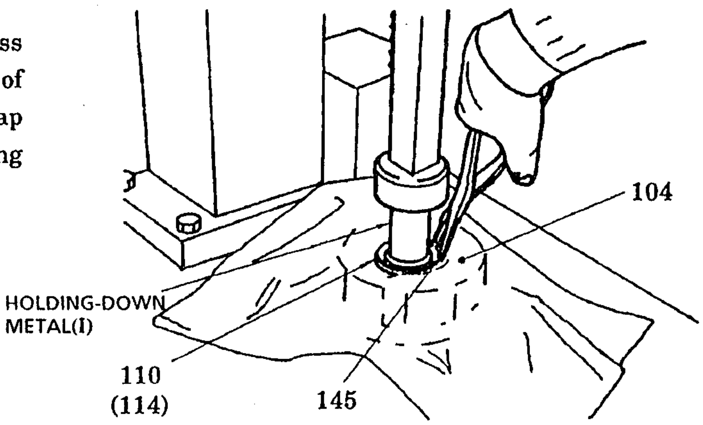


Fig. 43

2) Remove holding-down metal (I) and draw out snap ring (145), washer (110) and snap ring (114) from cylinder block (104).

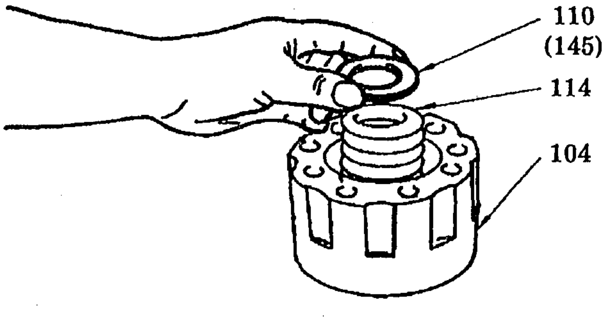


Fig. 44

(14) Drawing out drive shaft (102)

1) Draw out swash plate (103) from drive shaft (102).

☞ Take care as ball (167) may be adhered to the swash plate.

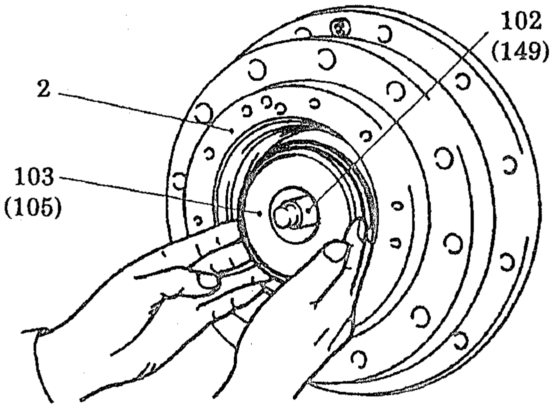


Fig. 45

2) Draw out drive shaft (102) from spindle (2). On that occasion, bearing (149) comes off together.

☞ The drive shaft comes off easily if you lightly tap the tip of the reduction unit side of the drive shaft.

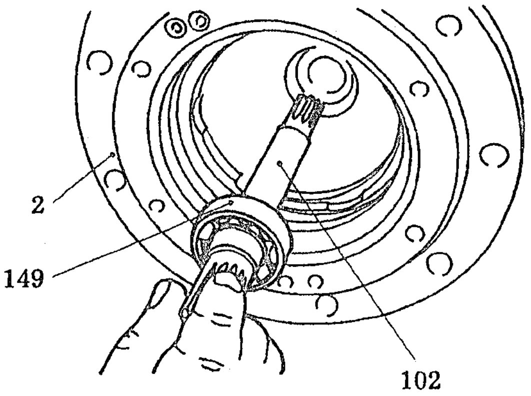


Fig. 46

3) Separate thrust plate (153) from swash plate (103).

☞ The thrust plate can easily be separated from the swash plate if you insert a spatula between the swash plate and the thrust plate.

4) Take out two balls (167) from spindle (2).

5) Blow in compressed air through the path (on the O. D. side) of spindle (2) and draw out the 2-speed changeover piston ass'y [consisting of piston (161) and shoe (162)] from spindle (2).

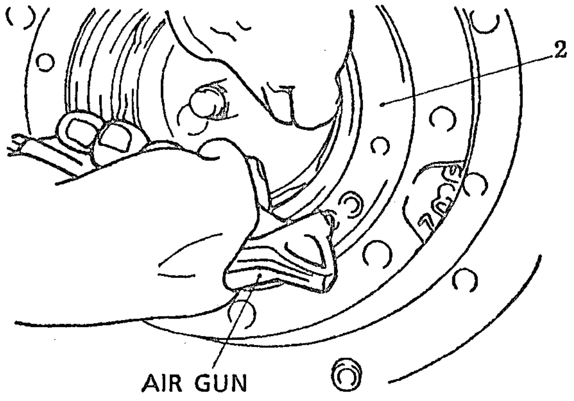


Fig. 47

☞ ○ Operating air pressures of 3~5kgf/cm^2 (43~71psi) are suitable.
○ Piston (161) and shoe (162) are reduced at the spherical part of the piston and make up an integral piston ass'y. If either of the two is faulty, replace both with a piston ass'y.

(15) Dismantling spur gear (7)

1) Turn over the travel motor body and remove three snap rings (25) from crank-shaft (9).
2) Draw out three spur gears (7) and three distance pieces (14) from crank-shaft (9).

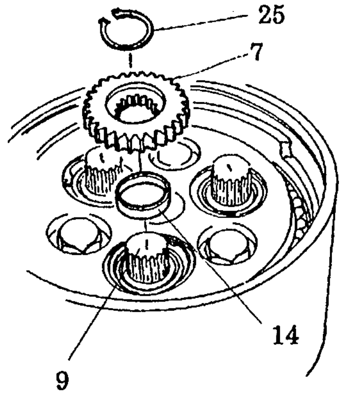


Fig. 48

(16) Dismantling hold flange (3)

1) Turn over the travel motor body upside down and fix two fixing metals between hub (1) and spindle (2).
   On that occasion, arrange two fixing metals in diagonally opposite positions.

☞ If you remove hold flange (3) without using fixing metals, hub (1) will come off spindle (2), with the result that spindle (2) falls off the work bench. Always use fixing metals.

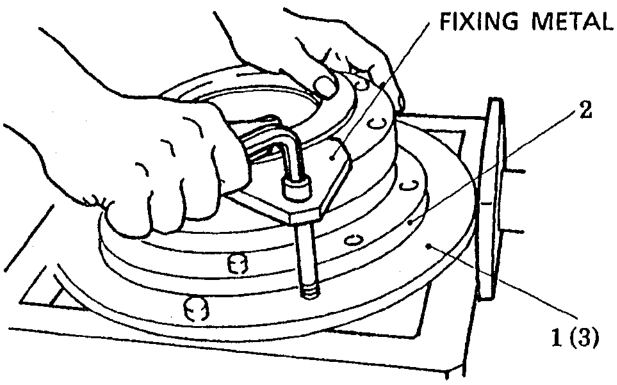


Fig. 49

2) Turn over the travel motor body again and separate three snap rings (20) from hold flange (3).

☞ Before removing snap rings (20), leave a matching mark on snap ring (20) and hold flange (3) with an oil paint marker so that they are assembled in the same positions at reassembly.

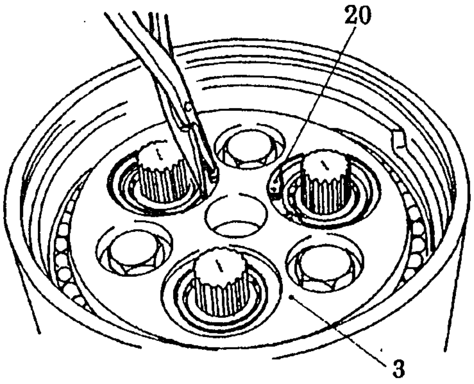


Fig. 50

3) Loosen three reamer bolts (19).

☞ Adhesive agent is used on the thread part of reamer bolt (19), and when the reamer bolt may be seized because of the adhesive stuck to the thread part. For this reason, loosen reamer bolt (19) as slowly as possible. In case it becomes hard to turn the reamer bolt during loosening, do not loosen it forcibly, but tighten it a little and then loosen it slowly once again.
The tightening torque is 37.6±6kgf · m (272±43ft · lbs). A torque more than it is needed to loosen the bolt.

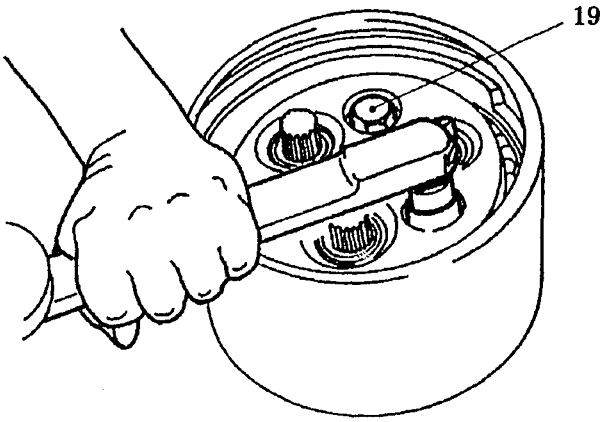


Fig. 51

4) Dismantle hold flange (3) from spindle (2).

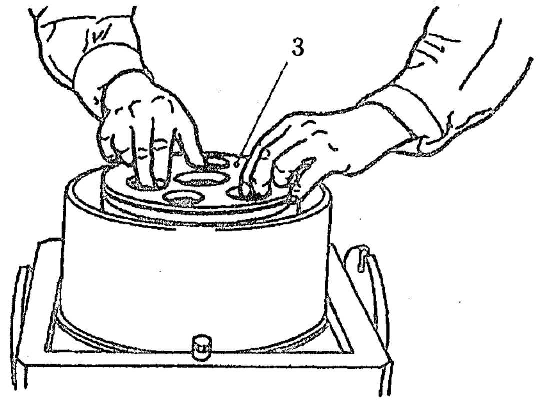


Fig. 52

☞ ◎ Mark hold flange (3) and unseparated spindle (2) with an oil paint marker so that they may be assembled in the same positions at reassembly.
◎ Since three reamer bolt (19) holes in spindle (2) are drilled at the same time, replace them with the spindle ass'y consisting of spindle (2) and hold flange (3) when either of them needs replacement.

(17) Dismantling spindle (2)

1) Turn over the travel motor ass'y with the flange of spindle (2) facing up and remove the fixing metals fixed at the tip.

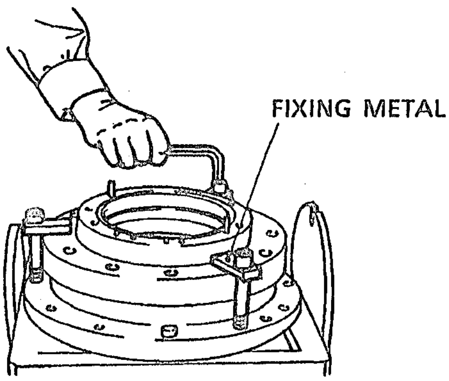


Fig. 53

2) Attach two eye bolts in diagonally opposite tapped holes to which spindle (2) is fixed.
3) Separate spindle (2) from hub (1), utilizing the eye bolts. On that occasion, floating seal (31), the outer race of bearing (22) and oil seal (132) come off together.

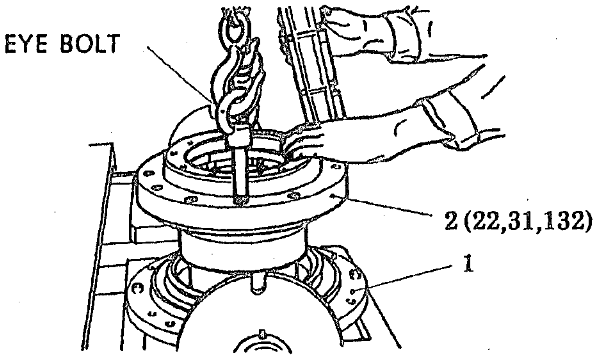


Fig. 54

4) Take out distance piece (10) from hub (1).
5) Separate O ring (28) form hub (1).

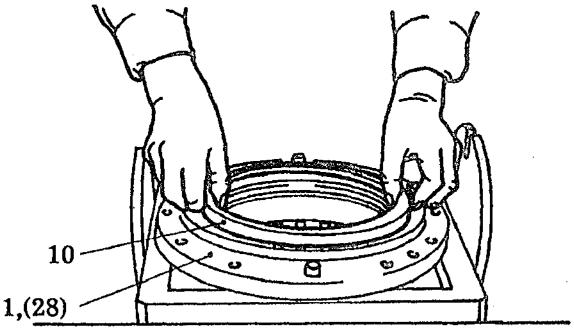


Fig. 55

(18) Removing the RV gear ass'y

1) Strike the end face of pin (17) by means of a pin punch and a hammer and remove bearing (21) from hub. On that occasion, the RV gear ass'y comes off together.

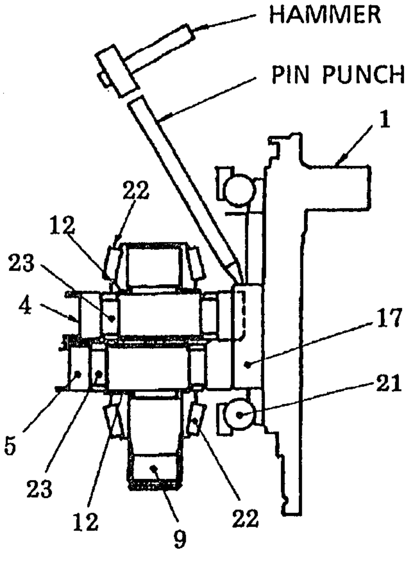


Fig. 56

☞
- Do not separate the RV gear ass'y as a rule. If the RV gear ass'y is separated and refitted, performances will be deteriorated.
- Construction of RV gear ass'y

RV gear A	(4)
RV gear B	(5)
Crank shaft	(9)
Spacer	(12)
Bearing	(22)
Bearing	(23)

- The RV gear ass'y is the minimum part unit. If any of the component parts must be damaged, replace the complete set of the RV gear ass'y.
  (Refer to the classification of parts in the Parts List.)
- Knock the end face of 3~4 pins on the circumference evenly little by little and draw out bearing (21) so it is not pried.
- When bearing (2) has come out of hub (1), the RV gear ass'y and pin (17) fall together. Therefore, place a container under which a rubber mattress is laid to receive falling parts so as to protect them from damage.

2) Remove fallen bearing (21), the RV gear ass'y and pin (17). It is so designed that RV gear A (4) and RV gear B (5) of the RV gear ass'y can be separated from crankshaft (9).

☞ Do not remove bearings (22, 23) and spacer (12) from crankshaft (9) except when necessary.

(19) Removing bearing (21) and collar (11)
Knock on the end face of collar (11) from the cover (8) side of hub (1) and draw out bearing (21) and collar (11) from hub (1).

☞ Prepare a rubber mattress to prevent the bearing and the collar from being damaged when they come off and fall down.

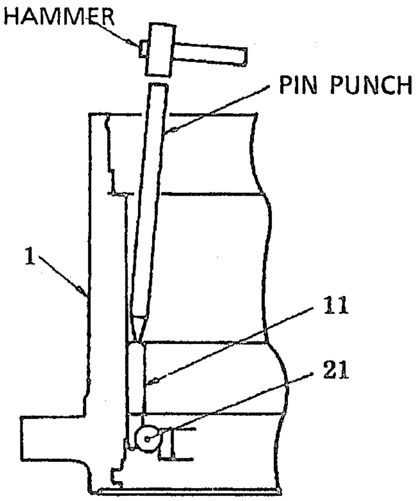


Fig. 57

(20) Disassembling the fittings of spindle (2)

1) Separate oil seal (132) from spindle (2).
2) Take out floating seal (31) from spindle (2).
3) Take out three outer races of bearing (22) from spindle (2).

☞ If the outer race of bearing (22) is in close contact with the mounting surface of the spindle, lightly tap the center of the mounting holes of the spindle by means of an aluminum rod till fittings comes off.

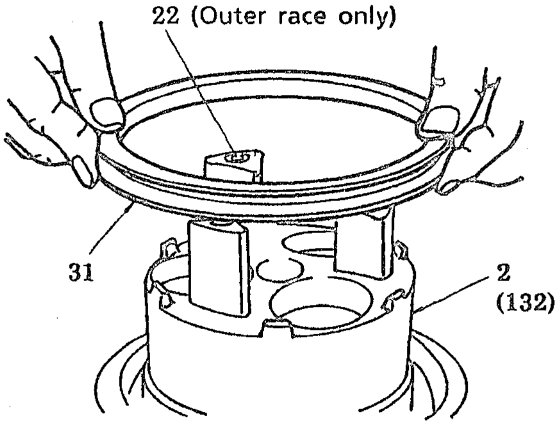


Fig. 58

(21) Disassembling the fittings of hold flange (3)
Take out the outer race of bearing (22) from hold flange (3).

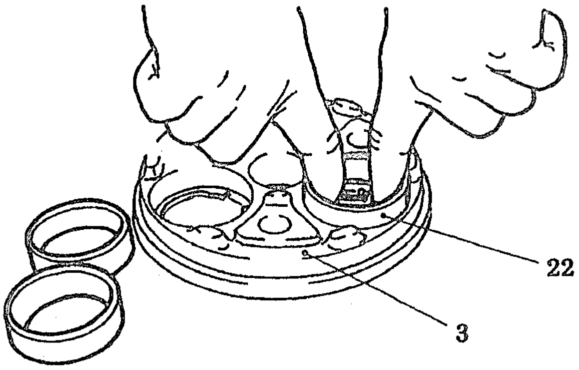


Fig. 59

(22) Rough washing of parts

1) Put outer parts such as, hub (1), spindle (2), cover (8) and rear flange (101) into a cleaning bath and wash them out.

☞ Clean the outer surface carefully as sand and soil remain on the surface.

2) Put other built-in parts in a rough cleaning container containing kerosene and clean them.

☞ If dirty parts are washed immediately in oil, they tend to be scored. Leave them immersed in kerosine till dirt and oily matter get loosen and come to the surface.

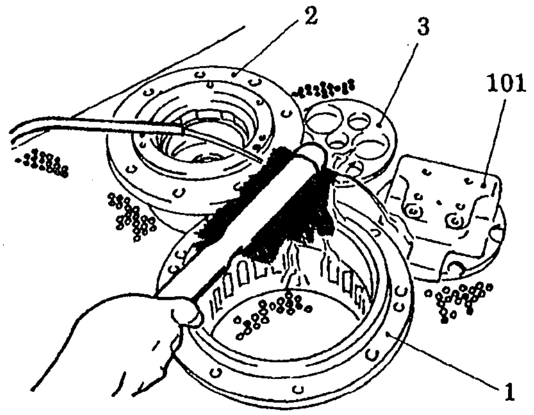


Fig. 60

(23) Finish cleaning

1) Put parts in a finish cleaning container containing kerosine and clean them well, turning them slowly.

2) Blow parts with jet air to remove kerosine adhered to them.

☞ ● To clean the inside surface of hub (1), spindle (2) and hold flange (3), blow them with jet air in a place free from dust and moisture. After drying the parts, coat parts with hydraulic oil.

● Dry the inside surface of rear flange (101), hydraulic motor parts and RV gear ass'y naturally in a place free from dust and moisture. After drying, coat parts with hydraulic oil.

● Note that if 24 pins (17) are handled roughly, they contact with each other, resulting from scoring of the surface and loss of pins.

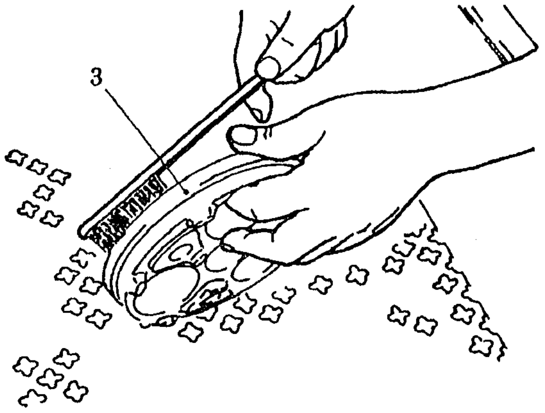


Fig. 61

4. ASSEMBLY

4.1 GENERAL PRECAUTIONS TO BE EXERCISED AT ASSEMBLY

(1) In principle, assembly is the reverse order of disassembly.

(2) For reassembly, choose a clean place.

(3) Do not use cloth gloves for reassembly.

(4) Replace or remedy those parts damaged during disassembly, referring to Service Standards. Always replace O rings and oil seals with new ones.

(5) Clean parts thoroughly with cleaning oil and let them dry with jet air. Do not use rag in any circumstances.

(6) Coat the moving part of the hydraulic motor valve with clean hydraulic oil before reassembly.

(7) Tighten capscrews and plugs to specified torques, using a torque wrench.

(8) Replace reamer bolts with new ones, in principle. In case they are used again, eliminate adhesive agent stuck to them and if the seat surface of the bolts is scored, recondition the scoring with an oil stone and degrease the reamer bolts.

(9) Apply a thin film of grease to the lip and the moving part of the O rings, oil seals and floating seals before fitting them.

(10) When assembly is over, plug all ports to prevent intrusion of foreign matter.

4.2 PREPARATION BEFORE PROCEEDING TO ASSEMBLY AND PROCEDURE FOR PREPARATION

(1) When replacing and reassembling parts, prestressing of bearings and thickness adjustment of snap rings are necessary.
Before proceeding to assembly, make sure that the following parts have been replaced.

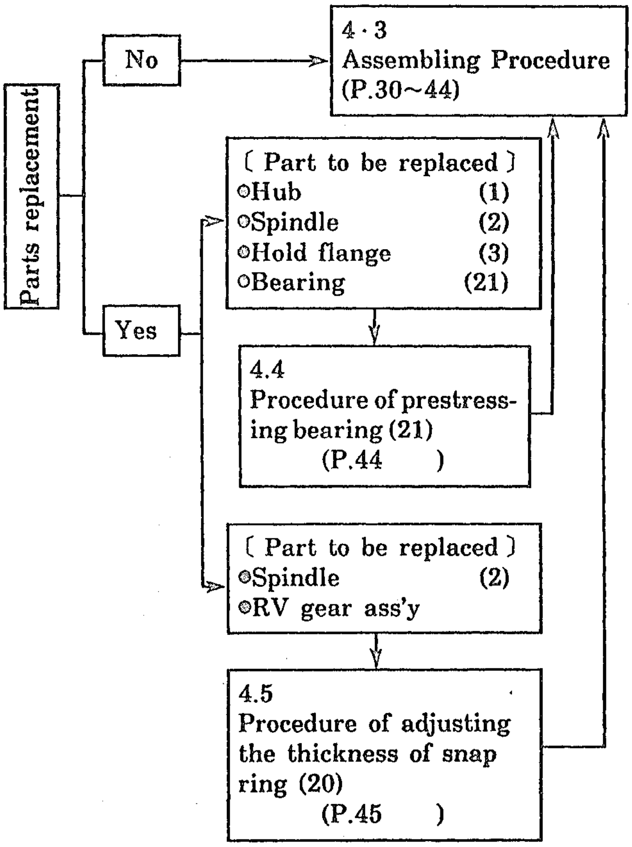
1) Parts requiring prestressing bearings

Hub	(1)
Spindle	(2)
Collar	(11)
Hold flange	(3)
Bearing	(21)

2) Parts requiring thickness adjustment of snap rings

Spindle kit	(2)
Hold flange	(3)
Crankshaft	(9)
Spacer	(12)
Bearing	(22)
Snap ring	(20)

(2) Presence or not of the above parts affects the assembly steps as follows:


Parts replacement
No
Yes
4·3
Assembling Procedure
(P.30~44)
[Part to be replaced]
◎Hub (1)
◎Spindle (2)
◎Hold flange (3)
◎Bearing (21)
4.4
Procedure of prestressing bearing (21)
(P.44)
[Part to be replaced]
◎Spindle (2)
◎RV gear ass'y
4.5
Procedure of adjusting the thickness of snap ring (20)
(P.45)

☞ ◎ Keep in mind that when proceeding to reassembly by replacing the above parts, always use reconditioned parts. Use of unconditioned parts will bring about malfunction and failure at an early stage.

4.3 ASSEMBLY PROCEDURE

(1) Assembling hub (1)

1) Insert collar (11) and bearing (21) into hub (1).

☞ Place a pin punch against the outer rim of bearing (21), hammer it lightly all around and press in the bearing little by little.

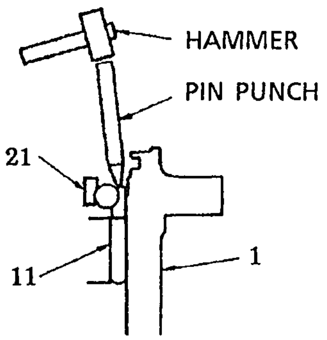


Fig. 62

2) Fit O ring (28) into the O ring groove of hub (1).

☞ Coat the O ring with grease.

3) Fit distance piece (10) to hub (1). If it is difficult to insert the distance piece, lightly tap it evenly by means of a plastic mallet.

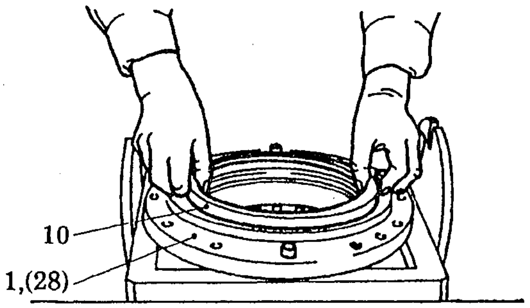


Fig. 63

(2) Assembling spindle (2)

Fix floating seal (31) into the floating seal groove of spindle (2).

☞
- Coat the O ring of floating seal (31) with a thin film of grease.
- To fix the floating seal, place the O ring into the groove of spindle (2) correctly and arrange the floating seal so the sealing surface of it is located in parallel with the spindle groove surface.

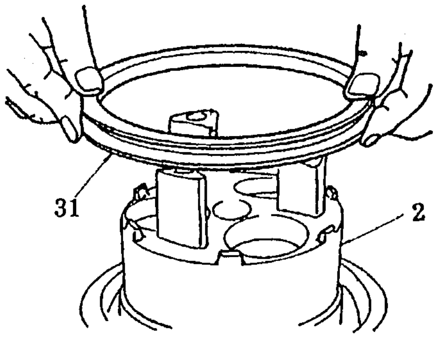


Fig. 64

(3) Assembling hub (1) with spindle (2)

1) Fit eye bolts (2 pcs) to spindle (2) in diagonally opposite positions.
2) Place the hook in the eye bolts and put spindle (2) into hub (1) slowly.

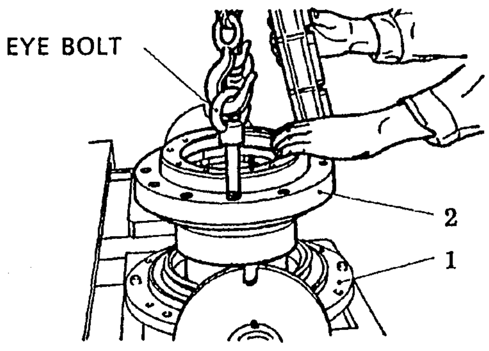


Fig. 65

3) Fasten and fix hub (1) and spindle (2) with two fixing metals.
On that occasion, place the fixing metals in diagonally opposite locations.

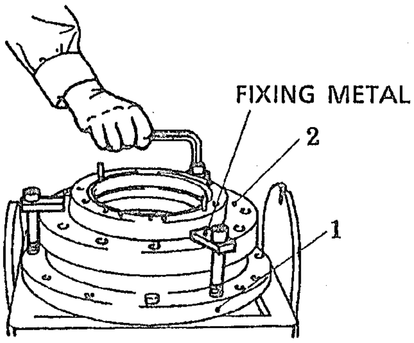


Fig. 66

4) Turn over the travel motor body so the cover comes up.
5) Fix three outer races of bearing (22) into the mounting holes in spindle (2).

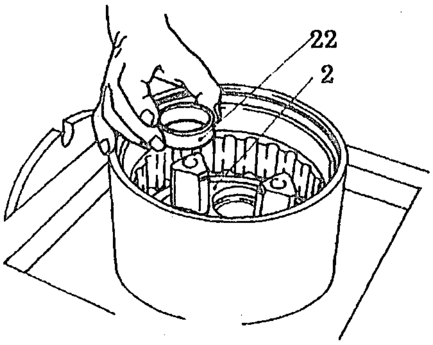


Fig. 67

(4) Fixing the RV gear ass'y
1) Fix the RV gear ass'y to spindle (2).

☞ ◎ Hold the tip of crankshaft (9) by both hands, match the inner race of the crankshaft bearing to the outer race hole of bearing (22) and attach the RV gear ass'y to the spindle.
Jerky dropping of the RV gear ass'y for the assembly purpose will score the bearing and cause malfunctioning of the travel motor.
◎ Since the phases of the teeth of RV gear A (4) and RV gear B (5) are matched correctly, place them by setting the punched holes at the ends to the same locations.

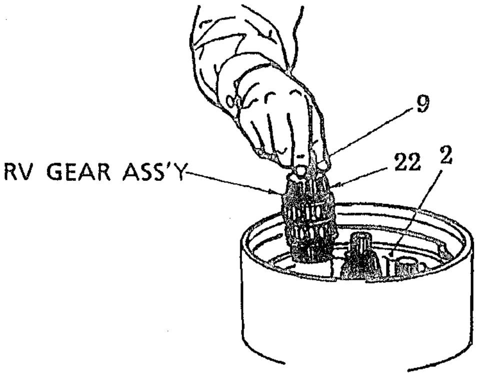


Fig. 68

2) Insert 24 pins (17) between the pin groove and the gear tooth groove of hub (1).

☞ Insert pins (17) after coating them with lube oil.

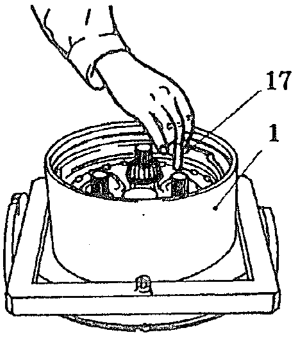


Fig. 69

(5) Fixing bearing (21)

1) Insert the outer race of bearing (21) into hub (1).

☞ Since the outside diameter of bearing (21) is press fitted to the bore of hub (1), the outer race of the bearing can not be fixed in hub (1). Place a pin punch against the outer rim of the outer race and lightly tap it evenly little by little till the outer race is set in place. Fix the outer race into the hub securely.

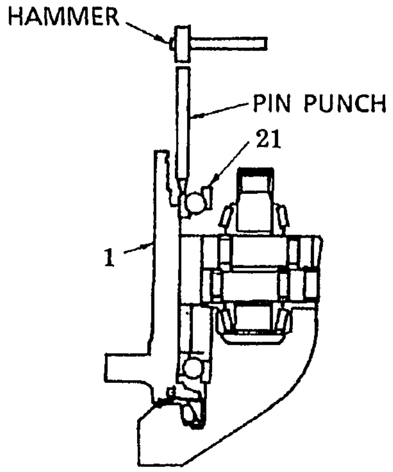


Fig. 70

(6) Fixing hold flange (3)

1) Fit hold flange (3) to the inner race of bearing (21) in hub (1).

☞ ● When fitting hold flange (3), align the matching mark on spindle (2) with that on crankshaft (9) and fix bearing (21) in the same location as before disassembly.

● In case hold flange (3) is hard to enter the inner race of ball bearing (21), lightly tap hold flange (3) with a plastic mallet evenly till bearing (221) is set.

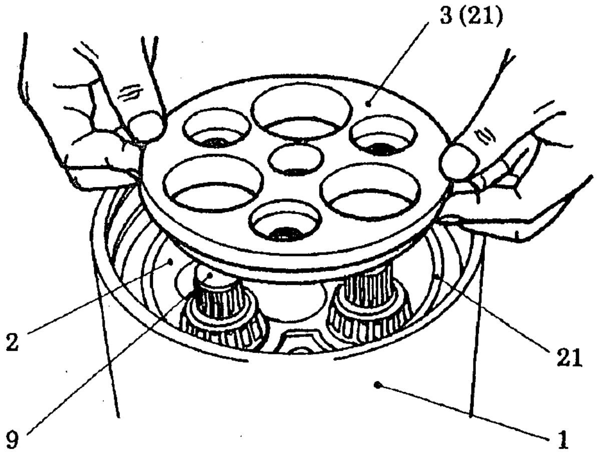


Fig. 71

(7) Tightening reamer bolt (19)

1) Coat the reaming part of reamer bolt (19) with antiseize agent and apply Locktite #638 to the screwed part.

☞ Apply adhesive agent to the reamer bolt after degreasing and drying it thoroughly.

2) Tighten reamer bolts (19) (3 pcs) to a specified torque.

☞ ● Tightening torque : 37.6±6kgf · m (272±43ft · lbs)

● Tighten three reamer bolts (19) evenly little by little. If one or two bolts are tightened up in the first place, hold flange (3) is inclined. This makes fixing of bearing (21) impossible to be set in the hold flange and causes reamer bolts (19) to be seized.

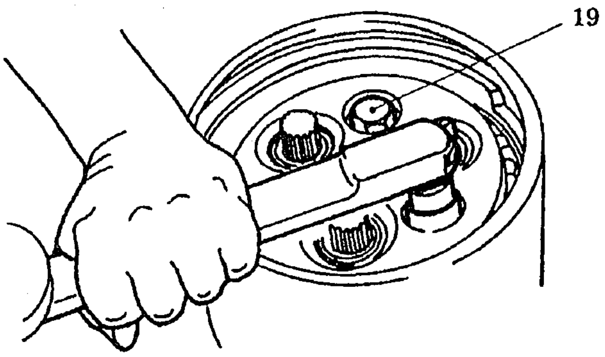


Fig. 72

3) Turn over the travel motor upside down, remove two fixing metals, turn it over once again and set the outer race of bearing (22) to hold flange (3).

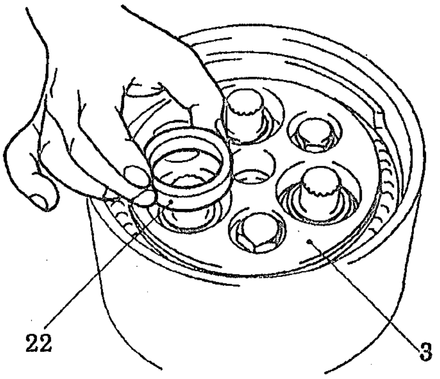


Fig. 73

(8) Fixing snap ring (20)

1) Fix snap ring (20) to the snap ring groove in hold flange (3).

☞ ◎ Match three snap rings (20) to the matching marks on hold flange (3) and set them in the same locations as before disassembly.

◎ If you wish to replace only snap rings (20) with new ones, choose snap rings of the same size as or sizes closest to the ones removed.

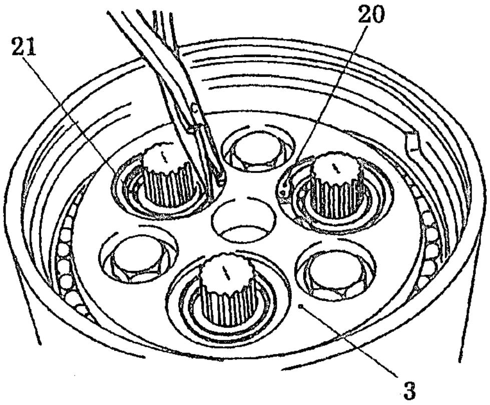


Fig. 74

2) Fit distance piece (14) to crankshaft (9).

(9) Assembling spur gear (7)

1) Align the matching mark positions of three spur gears (7) and fit them to crankshaft (9).

2) Fix snap rings (25) into the snap ring grooves of crankshaft (9).

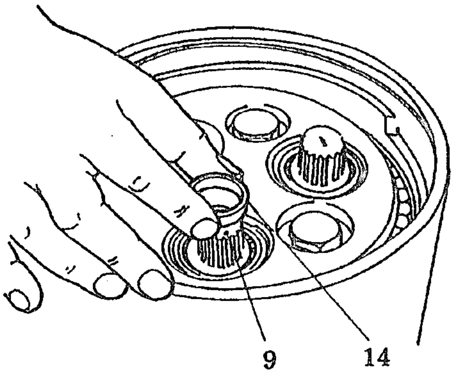
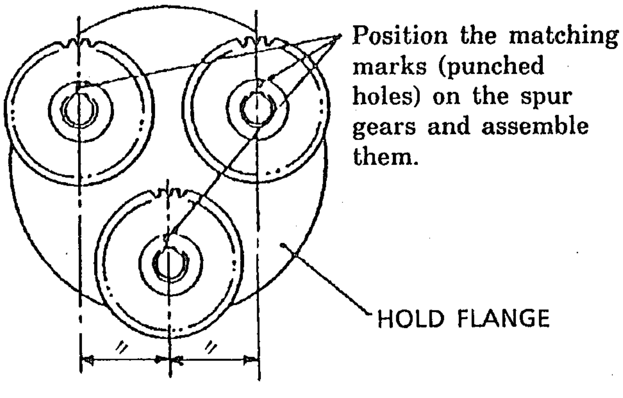


Fig. 75

☞ Set the matching marks (punched holes) of spur gears (7) and assemble them in the locations illustrated in the figure below:


Position the matching marks (punched holes) on the spur gears and assemble them.
HOLD FLANGE
//
//

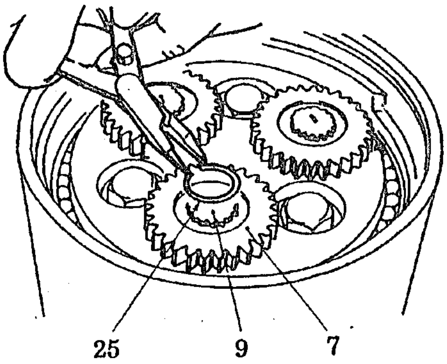


Fig. 76

(10) Pressing in oil seal (132)

1) Turn over the travel motor body.
2) Fix oil seal (132) into the oil seal fixing hole on spindle (2).

☞ • Coat the lip of oil seal (132) with white vaseline or lithium-base grease.
• When inserting the oil seal, use holding-down metal (Ⅲ) so the oil seal is set in place.

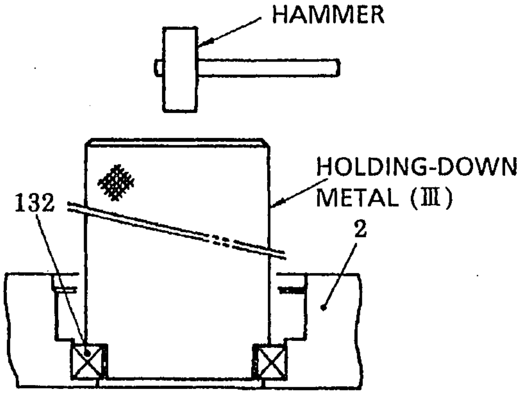


Fig. 77

(11) Fixing shaft (102)

1) Fix bearing (149) to shaft (102) by shrinkage fit.

☞ • For insertion, wear leather groves to protect yourself from burns.
• If you removed bearing (149) before disassembling the shaft, replace it with a new one and fix it by shrinkage fit.
• Shrinkage fit temperature : 100±10°C (212±50°F)
• Coat the outer contact surface of bearing (149) with molybdenum disulfide grease.

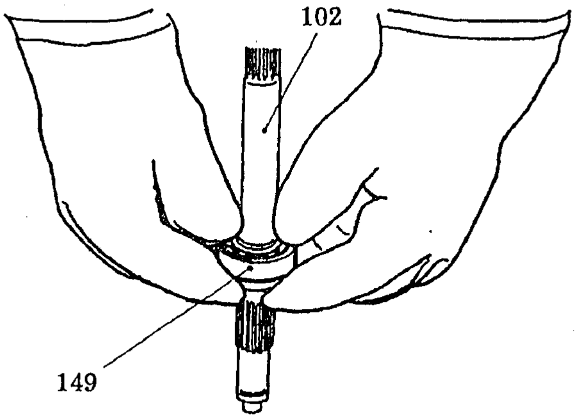


Fig. 78

2) Fit two balls (167) to spindle (2).

☞ Coat balls (167) with grease beforehand to prevent them from falling down.

3) Fix pistons (161, 162) to spindle (2).

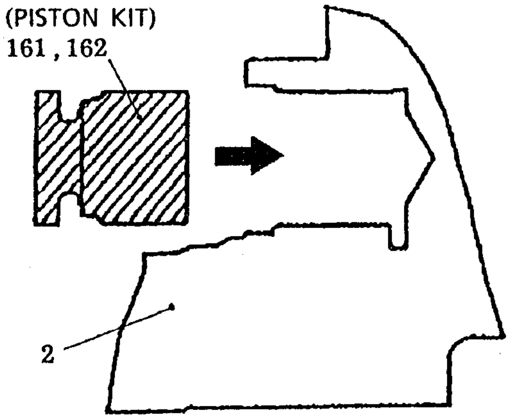


Fig. 79

4) Fit the travel motor so the center of the shaft is parallel and fix shaft to spindle (2).

☞ When fixing the shaft, do it gently so the lip of oil seal (132) is not scored.

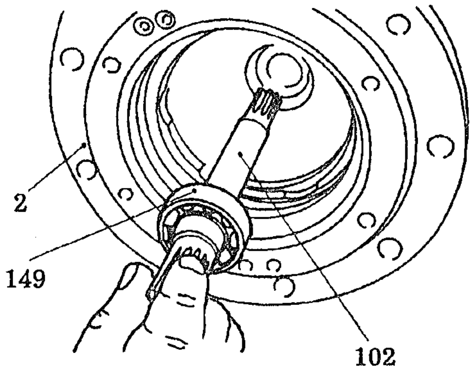


Fig. 80

5) Coat thrust plate (153) with molybdenum disulfide grease and fix swash plate (103).

6) Attach swash plate (103) to spindle (2).

☞ ◎ Coat the matching surface of spindle (2) of swash plate (103) with grease.
◎ Match two balls (167) fixed to spindle (2) with the ball holes on swash plate (103) and fix the swash plate to the spindle.

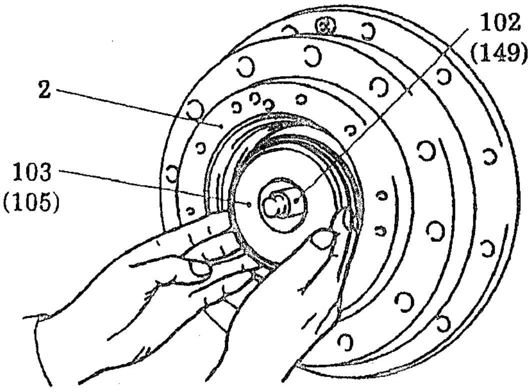


Fig. 81

(12) Assembling the cylinder block

1) Place washer (110), spring (114) and washer (110) into cylinder block (104) and fit snap ring (145).

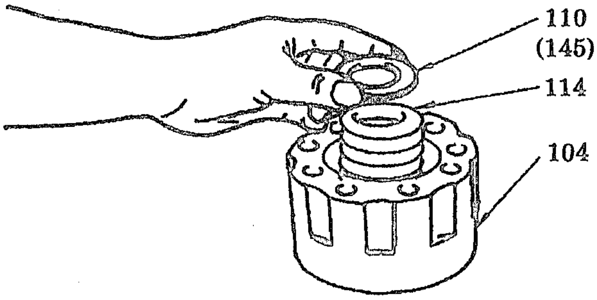


Fig. 82

2) Place the above-mentioned cylinder block (104) on a press bench, put holding-down metal (I) against washer (110), hold down spring (114) and fix snap ring (145).

☞ ◎ Cover the sliding surface of the cylinder block with a plastic sheet to protect it.

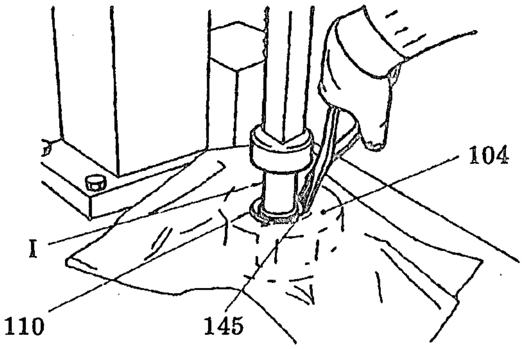


Fig. 83

(13) Assembling the hydraulic motor parts

1) Insert three pins (151) into cylinder block (104) and then mount thrust ball (108) on it.
2) Fit piston ass'y (105, 106) to retainer plate (107).
3) Attach the piston ass'y to cylinder block (104). After fixing it, immerse the whole unit in hydraulic oil.
4) Attach the piston (105) side of piston ass'y (105, 106) to cylinder block (104).

☞ Match retainer plate (107) with the spherical part of thrust ball (108) and fix them.

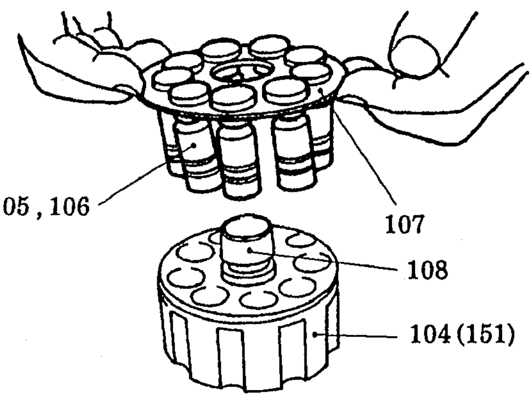


Fig. 84

5) Insert cylinder block (104) into shaft (102).

☞ ● The cylinder block and the shaft are jointed by a splined hole and a spline shaft. Do not drive them in by unreasonable force.

● After fixing the cylinder block, make sure that it has no gap and turns smoothly when rotating it by hand. In case of any abnormality, check it.

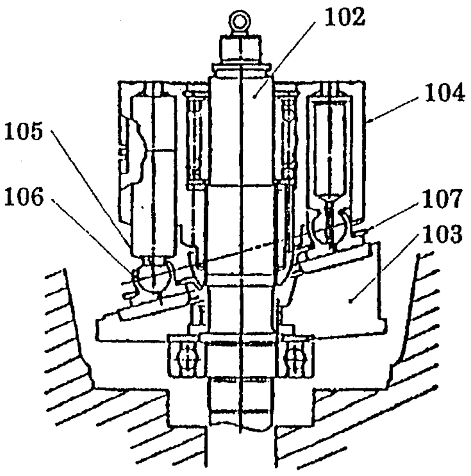


Fig. 85

(14) Assembling the parking brake

1) Fit two sets of plate (115 · · · friction plate) and (116 · · · companion plate) to the outer groove of cylinder block (104), in that order.

☞ ● Use care so as not to mistake the order of fixing the friction plate and the companion plate.

● Immerse plate (115) in hydraulic oil before fitting it.

2) Fit O rings (135), (139) and backup rings (147), (148) to the O ring grooves of piston (112) and then fix piston (112) into spindle (2).

☞ ● If it is hard to fit the piston into the spindle due to the resistance of O rings, lightly tap the end face of the piston, using a plastic mallet.

● Coat the O ring fitted to the piston with grease beforehand and fix it so it may not be scored.

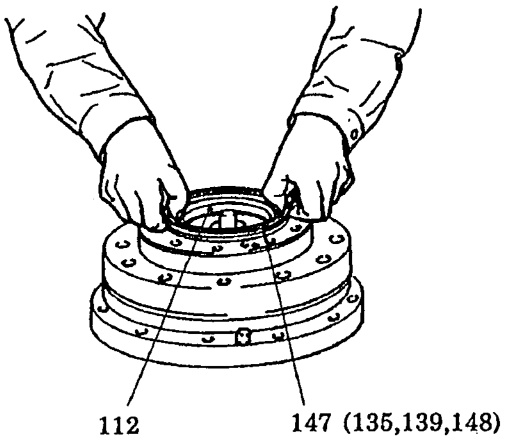


Fig. 86

(15) Assembling the brake valve parts into rear flange (101)

1) Fit O ring (137) to plug (126).

☞ Coat O ring (137) with grease.

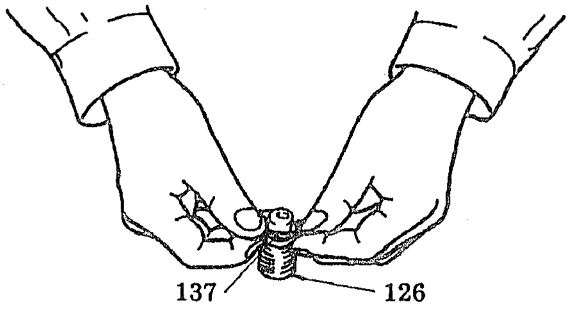


Fig. 87

2) Put spring (130) and valve (127) into plug (126), apply grease to valve (127) and spring (137) and temporarily secure spring (130).

3) Put integrated plug (126) into rear flange (101) and fasten it temporarily.

☞ ○ When fitting plug (126), place the rear flange (101) onto the work bench with its plug fixing screwed face up and then center the screw with the plug correctly.
This is to prevent damage to O rings and prevent valve (127) from taking off spring (130), which results in improper seating of the valve.

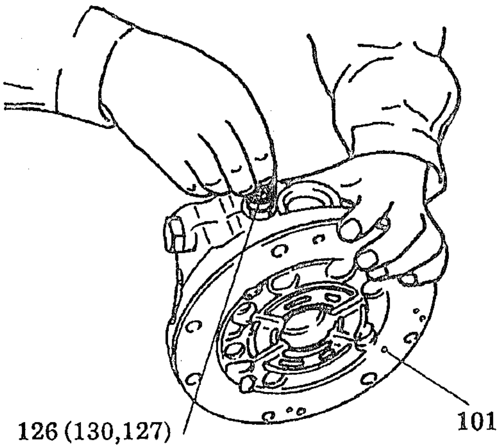


Fig. 88

4) Insert spool (123) into rear flange (101).

☞ ◎ Coat spool (123) with hydraulic oil before fitting it.
◎ Align the center of the holes in the rear flanges with the center of the spool before fixing the spool. This is to prevent damage to the inner surface of the rear flange and the outer surface of the spool as the result of mutual interference.
◎ In case damage resulting from interference should occur to the holes in the rear flange and the outer surface of the spool, internal leaks will occur after assembly, ultimately deteriorating the performances of the travel motor.

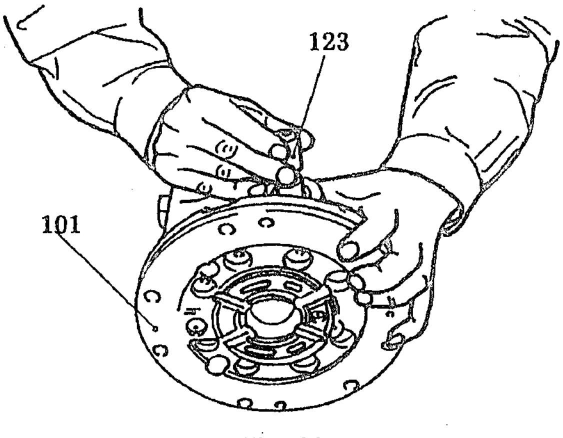


Fig. 89

5) Fit O ring (136) to plug (124).

☞ ● Coat O ring (136) with grease.

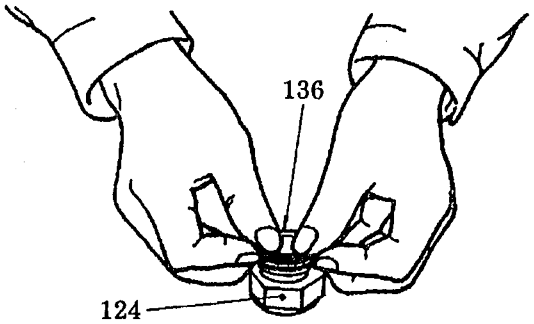


Fig. 90

6) Fit spring retainer (125) and springs (128), (129) to plugs (124) and fasten the plugs to rear flange (101) temporarily.

☞ ● When replacing rear flange (101) or spool (123), always replace it with a rear flange kit.

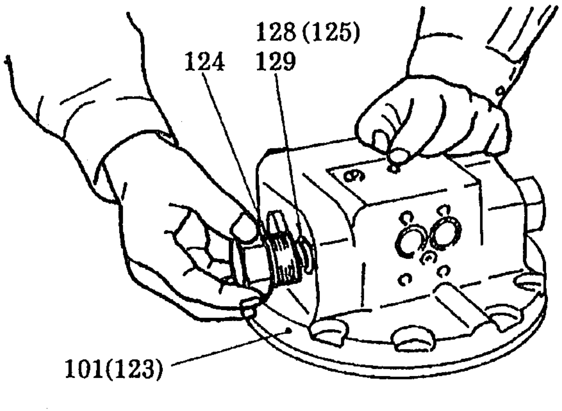


Fig. 91

(15) Assembling the surge cut valve

1) Insert surge cut spool (156) into surge cut valve body (155). On that occasion, coat surge cut spool (156) with hydraulic oil before fixing it into surge cut valve body (155).

☞ ● When fitting surge cut spool (156), align the center of surge cut valve body (155) to the center of the spool. This aims at preventing damage to the inner surface of the body and the outer surface of the spool because of interference.

● If damage occurs to the holes in the body and the outer surface of the spool by interference, it brings about internal leaks after assembly and results in deteriorated performances of the motor.

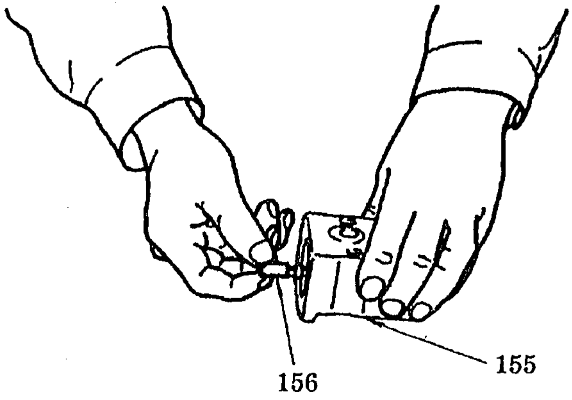


Fig. 92

2) Attach O ring (136) to plug (160).

☞ ◎ Apply grease to O ring (136).

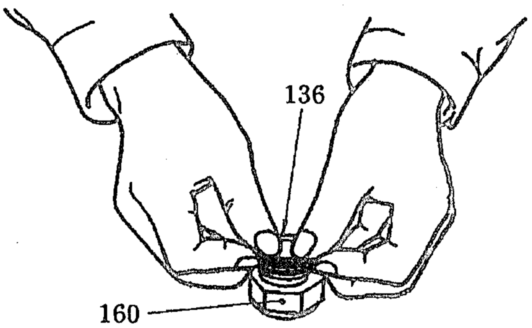


Fig. 93

3) Put stopper (157) and springs (158), (159) into surge cut valve body (155).

4) Temporarily fasten plug (160) to surge cut valve body (155).

☞ ◎ When screwing plug (160) into body (155), use care so that springs (158) (159) are not distorted.

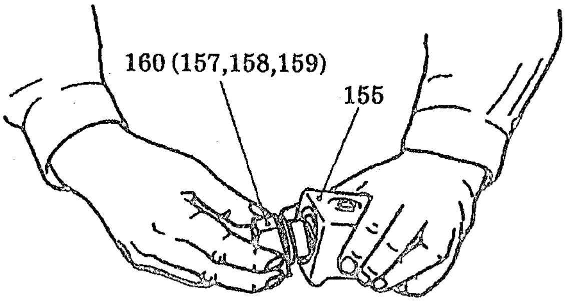


Fig. 94

(16) Fitting pilot valve (163) to rear flange (101)

1) Place spindle (2) with its matching surface up and insert pilot valve (163) into rear flange (101).

2) Place spring (166) and stopper over pilot valve (163), in that order.

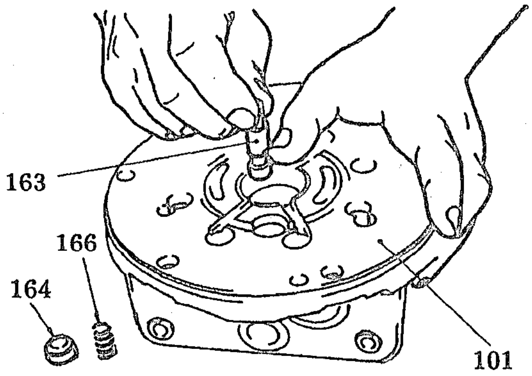


Fig. 95

3) Fold new ring (165) a little inwards, press it in from above stopper (164), place it in the ring groove of rear flange (101) and then secure it firmly.

☞ ◎ Always replace ring (165) with a new one.
◎ After inserting ring (165), make certain that it is set correctly in the ring groove all around.
Incomplete setting will make the function of pilot valve (163) unstable, thereby disabling selection of high and low speeds.

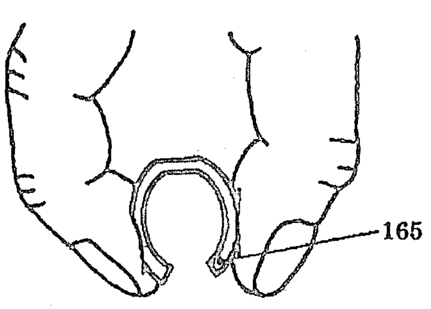


Fig. 96

(17) Fitting parking brake valve (119)

1) Fit O ring (133) to valve seat (118).

☞ • Coat O ring (133) with grease.

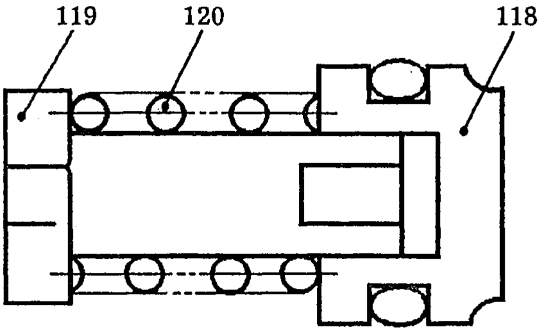


Fig. 97

2) Fit valve (119), spring (120) and valve seat (118) to rear flange (101) in sequence.

3) Curve new ring (122) inwards and fix it into the ring groove of rear flange (101).
The method of fixing is the same as pilot valve (163).

☞ • Use a new ring (122).

(18) Attaching other rear flange (101) fittings

1) Coat bearing (150) with hydraulic oil and put it into rear flange (101).

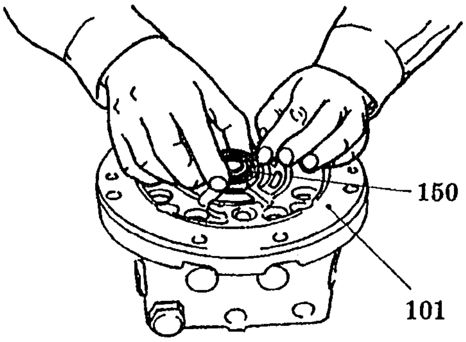


Fig. 98

2) Drive in two parallel pins (141) into the pin holes of rear flange (101)

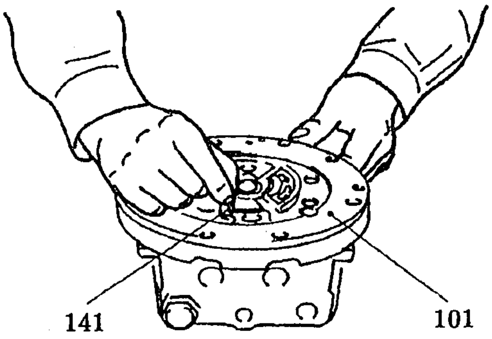


Fig. 99

3) Apply grease to the area of timing plate (109) in contact with rear flange (101) and attach it to rear flange (101), using parallel pins (141) as guides.

☞ Attaching timing plate (109) in close contact with rear flange (101) prevents the timing plate from falling down when the rear flange is fixed to spindle (2).

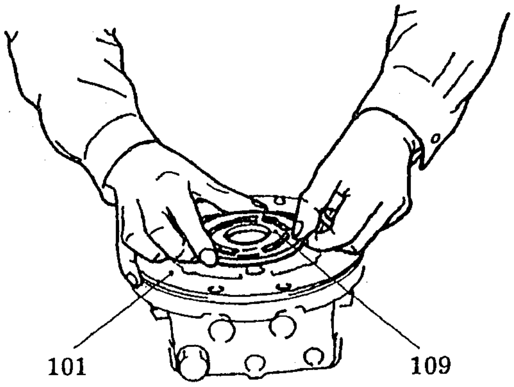


Fig. 100

(19) Connecting rear flange (101) with spindle (2)

1) Put O rings (30) (27) and parallel pin (142) to the spindle (2) side and then fit rear flange (101) to spindle (2).

☞ ◎ Fill hydraulic oil (0.55ℓ (0.15gal)) into spindle (2).
◎ Do not coat O ring (30) in the matching surface with grease. (because oozing out of grease tends to be mistaken as an oil leak.)
◎ When installing rear flange (101), match the pin holes to two parallel pins (142) fixed in spindle (2).

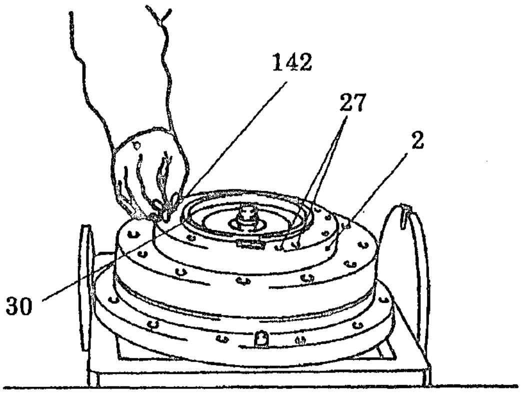


Fig. 101

2) Attach rear flange (101) to spindle by matching two parallel pins (142) fixed in spindle (2) to the pin holes of the rear flange.

☞ Before fitting rear flange (110) to spindle (2), set eight springs (113) to the rear flange side. Coat the outer surface of spring (113) with grease and fix it to prevent the spring from falling.

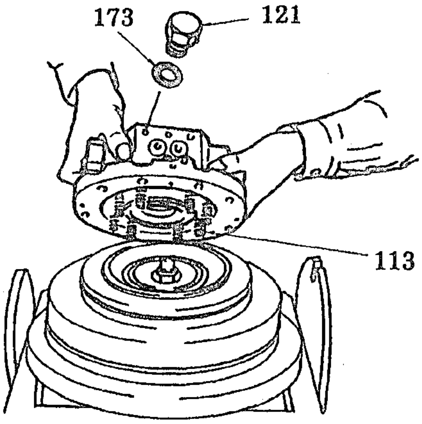


Fig. 102

3) Tighten nine socket head capscrews (143) to spindle (2) to a specified torque.

☞ ◎ Tightening torque : 5.9±1.0kgf · m (43±7ft · lbs)

4) Fit O ring (173) to plug (121) and fit it to an unpiped drain port.

☞ Perform this operation only when plug (121) is separated.

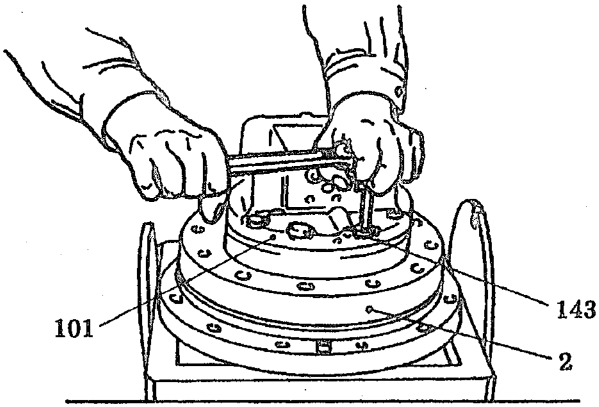


Fig. 103

5) Fit O rings (140) (138) to rear flange (101).
6) Attach body (155) to rear flange (101).
7) Tighten capscrews (170) against rear flange (101) to a specified torque.

☞ ● Tightening torque : 3.0±0.5kgf · m (22±4ft · lbs)

8) Tighten plugs (124), (160) to a specified torque:
Tightening torque : 17.0±2.5kgf · m (123±18ft · lbs)
9) Tighten plug (126) to a specified torque:
Tightening torque : 9.0±1.5kgf·m (65±11ft·lbs)

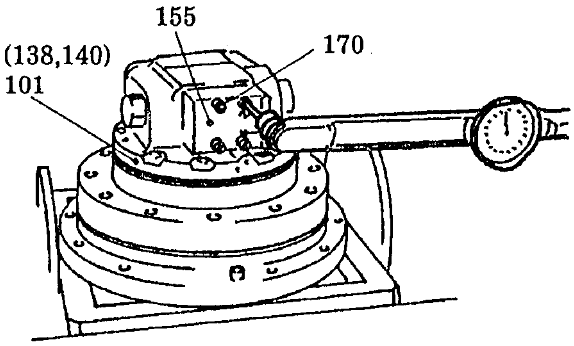


Fig. 104

(20) Assembling input gear (6)
1) Turn over the preassembled section of the travel motor upside down and fit coupling (15) to shaft (102).
2) Attach shaft (16) to coupling (15).
3) Attach input gear (6) to shaft (16) and fix snap ring (24) into the snap ring groove of the shaft.

☞ Fix input gear (6) to shaft (102) by matching the teeth of three spur gears (7). If the teeth do not engage, it is a fault. In that case, check for the cause.

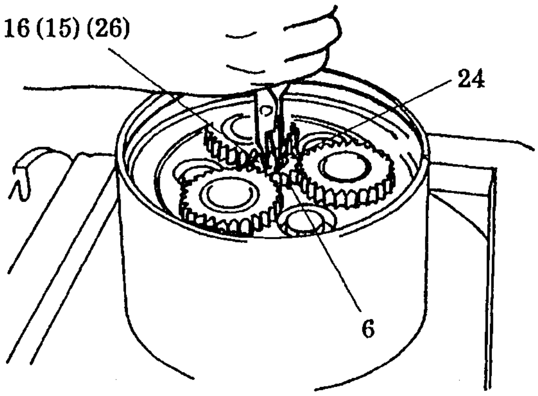


Fig. 105

4) Fit ball (26) into the ball fixing hole of shaft (16).

☞ Coat ball (26) with grease beforehand so that cover (8) does not fall off.

(21) Fitting cover (8)
1) Fit O ring (29) to cover (8).
2) Attach eye bolts to the screwed holes of cover (8) (to which plugs are screwed in), lift cover (8) up and put it into hub (1).

☞ ● Coat O ring (29) with grease. Use care so the O ring is not scored when placing the cover.
● Fix the cover in the same location as before disassembly, referring to the matching marks left between cover (8) and hub (1) at disassembly.

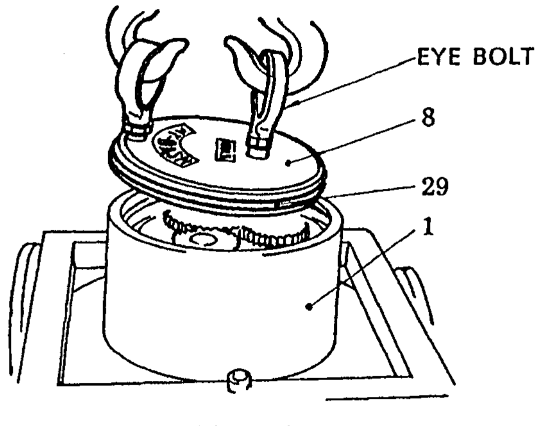


Fig. 106

☞ ◎ Prior to fixing cover (8), fill lube oil into hub (1).
Volume of lube oil : 1.7ℓ (0.45gal)

3) Fix ring (18) into the ring groove of hub (1) and fix cover (8).

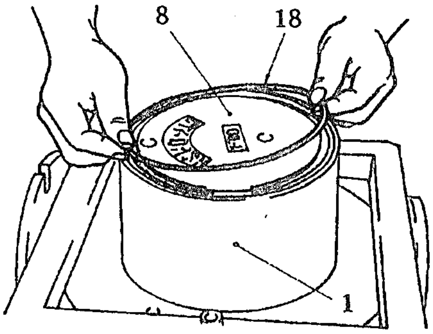


Fig. 107

4) If socket head capscrews (33) fixed to cover (8) were separated, place seal tape around the screwed part.
Tighten up the plug till ±1 thread remains above the end face of the cover.

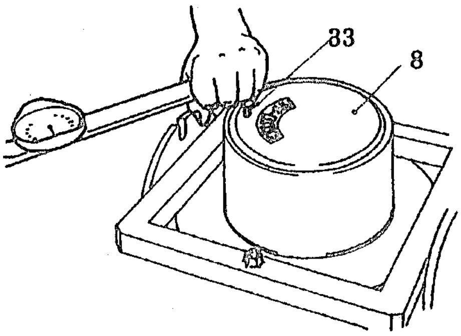


Fig. 108

4.4 PROCEDURE OF PRESTRESSING BEARING (21)
In case parts affecting the amount of prestressing were replaced to maintain the service life of bearing (21) to a suitable level, assemble them as follows and confirm the amount of prestressing.

☞ Make sure of the amount of prestressing at the completion of each of the operating steps (1), (2), (3), (4) and (5) under 4.3 Assembling Procedure.

(1) Attach a clearance measuring jig to spindle (2).
(2) Tighten the special nuts of the clearance measuring jig to a specified torque.

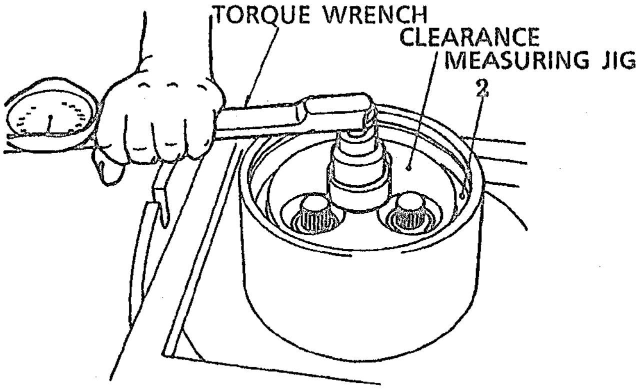


Fig. 109

☞ ◎ Tightening torque : 4kgf · m (29ft · lbs)

(3) Determine the depth "A" through the measuring hole of the clearance measuring jig, using a depth micrometer.
(4) Since the dimension "B" of the clearance measuring jig, the appropriate dimension "C" at prestressing is given by the following formula :
"C" = "A" − "B" A : Actual value
B : Dimensions of jig body
C : Appropriate dimension at prestressing

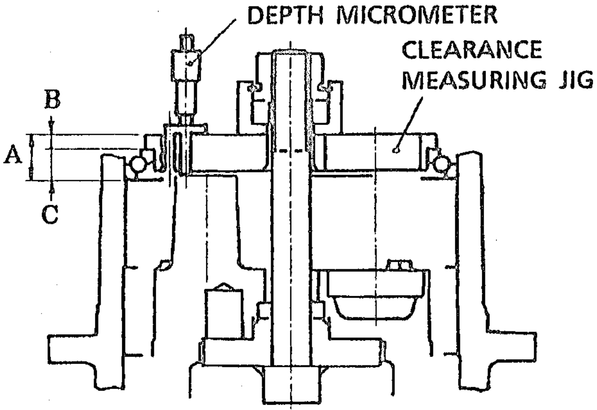


Fig. 110

(5) Then, make the dimension "D" of hold flange (3) D=C.

(6) After completion of measuring steps (3)~(5), adjust hold flange (3) as follows:

1) Where actual dimension "D" of hold flange (3) is smaller than dimension "C";
Remove the surface E of hold flange (3) to dimension "C" on a lath.

2) Where actual dimension of the hold flange falls within the tolerance ±0.01 (0.0004");
Use the present hold flange without machining.

3) Where actual dimension of the hold flange is larger than dimension "C";
Replace the hold flange with a new spindle ass'y.
Hold flange (3) is always provided with allowance for adjustment.

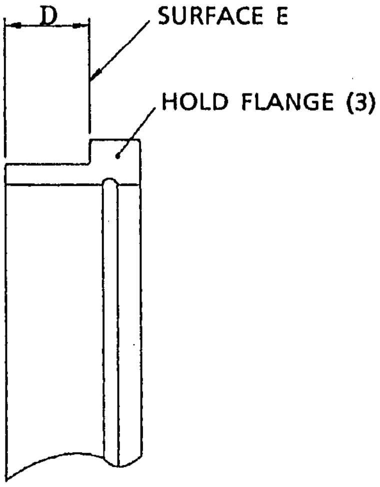


Fig. 111

(7) Remove the clearance measuring jig from spindle (2).

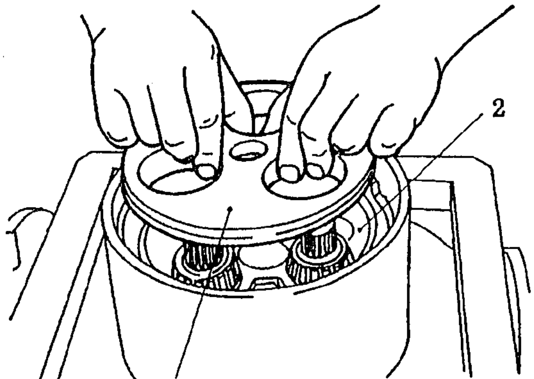


Fig. 112

4.5 PROCEDURE OF ADJUSTING THE THICKNESS OF SNAP RING (20)

The axial clearance of bearing (22) must be held to a specified level. Therefore, when a section affecting the clearance was replaced, adjust the following:

☞ When each of the operating steps (1)~(7) under 4.3 Assembling Procedure has been completed, determine required thickness as follows:

(1) Knock on the outer race of bearing (22) fixed to crankshaft (9) of the RV gear ass'y lightly by means of the holding-down metal (Ⅳ) and a hammer. (See Fig. 114.)

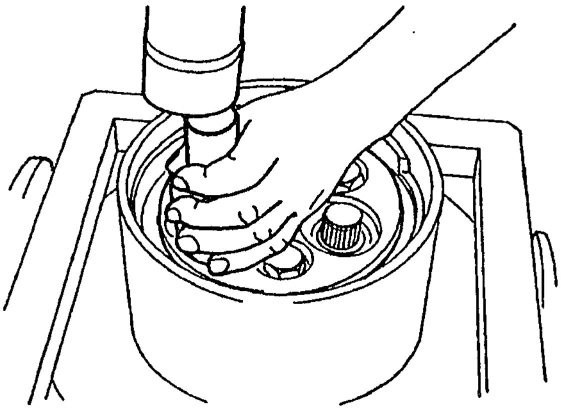


Fig. 113

☞ • Make sure that the RV gear ass'y is set in spindle correctly.

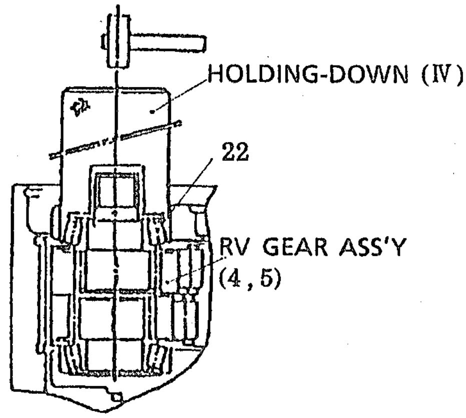


Fig. 114

(2) Fix the thinnest snap ring (20) into the snapring groove in hold flange (3).

(3) Lightly tap the outer periphery of snap ring (20), using holding-down metal (Ⅳ) and a hammer.

☞ ○ Confirm that the RV gear ass'y is snugly set in spindle (2).

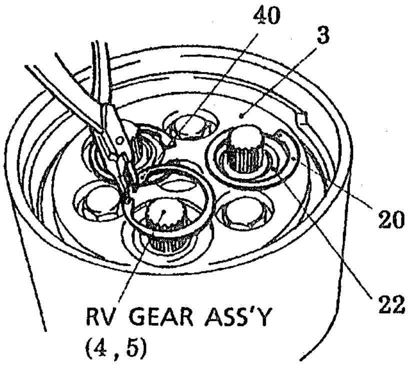


Fig. 115

(4) Insert a thickness gauge between snap ring (20) and conical roller bearing (22) and measure the clearance.

Thickness measurement of snap rings

① Set thickness of snap ring (max.)

MAX. = $\boxed{\text{Thickness of thickness gauge}}$ + $\boxed{\text{Thickness of presently set snap ring}}$

② Set thickness of snap ring (min.)

MIN. = $\boxed{\text{Thickness of thickness gauge}}$ + $\boxed{\text{Thickness of presently set snap ring}}$ − $\boxed{\text{0.05mm (0.002")}}$

(5) When the thickness of the snap ring has been determined, choose one out of twelve kinds A through L and fit it to the hold flange.

☞ ● Refer to List of Clearance Adjusting Parts (P. 47).

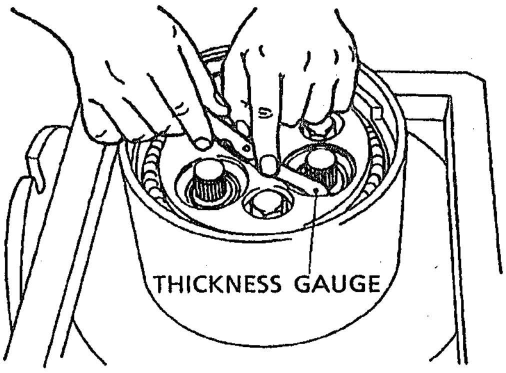


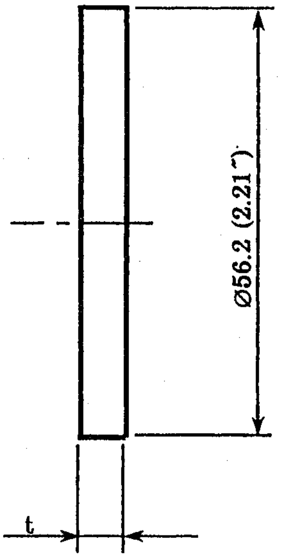
Fig. 116

5. A LIST OF SEAL KIT

No.	NAME OF PART	Q'ty	REMARKS
1	O RING	2	SYMBOL 27
2	O RING	1	28
3	O RING	1	29
4	O RING	1	30
5	FLOATING SEAL	1	31
6	OIL SEAL	1	132
7	O RING	1	133
8	O RING	1	135
9	O RING	2	138
10	O RING	1	139
11	O RING	3	140
12	BACK UP RING	1	147
13	BACK UP RING	1	148
14	O RING	3	155
15	O RING	2	156
16	O RING	1	173

6. TABLE OF DIMENSIONS OF CLEARANCE ADJUSTING PARTS

No.	NAME OF PART / GM MODEL	GM09VL
1	SNAP RING [20]	



Grouping	Dimension t mm (in)	
A	Over 1.90(0.075") to	1.95(0.077") incl.
B	〃 1.95(0.077")	2.00(0.079")
C	〃 2.00(0.079")	2.05(0.081")
D	〃 2.05(0.081")	2.10(0.083")
E	〃 2.10(0.083")	2.15(0.085")
F	〃 2.15(0.085")	2.20(0.087")
G	〃 2.20(0.087")	2.25(0.089")
H	〃 2.25(0.089")	2.30(0.091")
I	〃 2.30(0.091")	2.35(0.093")
J	〃 2.35(0.093")	2.40(0.094")
K	〃 2.40(0.094")	2.45(0.096")
L	〃 2.45(0.096")	2.50(0.098")

7. PERFORMANCE VERIFICATION TEST

5.1 PERFORMANCE INSPECTION

After completion of maintenance of the GM motor, perform the following performance verification test:

(1) Installing and Piping the GM Motor

1	Pressure gauge〔35kgf/cm^2 (498psi)〕	2 pcs
2	Measuring cylinder〔5 lit. (1.32gal)〕	1 pcs
3	Stop watch	1 pcs

(2) Test Procedure

1 Installing and Piping the GM Motor …… Install the GM motor to the body (sprocket side) and pipe it. However, do not install the crawlers. [This is to perform a performance test (no load run) of the GM motor.]

Note) 1. Attach a pressure gauge (main circuit) during piping and pipe so that the drain rate of the GM motor can be measured.

2. When installing the GM motor, do not tap it by hammer, but install it gently, utilizing the bolt holes.

2 Running in the GM Motor ……

	GM motor rev.	Pressure	Rotating direction	Operating time
1	10rpm	No load	Left / Right	For more than 1 min. each
2	20rpm			

3 Performance Verification Test of GM Motor

1 Preparatory Running before Test …… Execute preparatory running till the below temperature is reached.

◎ Hydraulic oil temperature 45~55°C (113~ 131°F)

◎ Outside temperature of reduction unit hub 40~80°C (104~176°F)

2 Verification Test …………… Measure the following items and determine conformity.

Acceptance criterion – Drive press. of GM motor 16kgf/cm^2 (228psi) or under/10rpm

(I speed) Amount of drain from hydraulic motor 0.5ℓ/min (0.132gal/min) or below/10rpm

Acceptable → Install a crawler.

Not acceptable → Disassemble and adjust once again.

7.2 SERVICE STANDARDS FOR PARTS

When disassembling and inspecting the GM motor, follow the standards set forth herein. Handle parts with caution, particulary the moving and sliding parts, so as not to score them. Replace any part that shows outstanding damage on appearance.

Replace such parts that show the following abnormalities, as well.

Replace all seals once disported even if no damage is seen.

Part No.	Nomenclature	Symptom	Reference value (Standard dimension)	Allowable value (Criterion)
	Spindle kit			
(2) (3) (19)	Spindle Hold flange Reamer bolt	• Critical damage to appearance • Abnormal wear such as gnawing is present.		
	RV gear ass'y			
(4) (5) (9) (22) (23)	RV gear (A) RV gear (B) Crankshaft Bearing Bearing	• The RV gear tooth surface shows uneven wear. • Crankshaft-related parts do not move smoothly when crankshaft (9) is turned.		
10	Distance piece	• Sliding surface is scored. • Sliding surface is abnormally worn.		
20	Snap ring	• The and face of the circumference is abnormally worn.		
21	Ball bearing	• Pressed mark is present. • Flaking is seen. • Uneven wear is present.		
	Rear flange kit			
(101)	Rear flange	• Part in contact with spool (123) is scratched. • Clearance with spool is large. • Surface in contact with valve (127) is scratched. • Depth to the contact surface with valve (127) is large.	Clearance on diameter 12~18μ (0.0005"~0.0007")	Clearance on diameter 23μ (0.0009")
(123)	Spool	• Outer circumference is scored. • Outer circumference is worn unevenly.		
102	Shaft	• Contact surface with oil seal (132) is worn. • Spline is worn.		
103	(Swash) plate	• Seizure is present.		

Part No.	Nomenclature	Symptom	Reference value (Standard dimension)	Allowable value (Criterion)
104	Cylinder block	◎ Spline is worn. ◎ Bore surface is worn badly. ◎ Sliding surface with timing plate (109) is scored or worn unevenly.		
 (105) (106)	Piston Ass'y Piston Shoe	◎ Clearance is present in the axial direction between piston (105) and shoe (106). ◎ Shoe is worn abnormally. ◎ Shoe is worn unevenly.	Clearance 0.05mm (0.0020")	0.15mm (0.0059")
107	Retainer plate	◎ The end face of the circumference is worn unevenly.		
108	Thrust ball	◎ Spherical sliding part with retainer plate (107) is worn unevenly.		
109	Timing plate	◎ Sliding surface is seized or worn unevenly.		
115 116	Wear plate Companion plate	◎ Both end faces are worn unevenly. ◎ Specified torque can not be reached. ◎ Seizure is seen.	Braking torque 8.4 kgf · m (61 ft·lbs) or over	Braking torque 8.4 kgf · m (61 ft·lbs) or under
118	Valve seat	◎ Seat surface is scored.		
119	Valve	◎ Outer circumference is scored. ◎ Seat surface is scored.		
 (155) (156)	Body kit Body Spool	◎ Sliding surface with spool (156) is scratched. ◎ Clearance with spool (156) is large. ◎ Outer circumference is scored. ◎ Outer circumference is worn unevenly.	Clearance on diameter 7~15μ (0.0003"~0.0006")	20μ (0.0008")
149 150	Bearing Bearing	◎ Pressed mark is present. ◎ Flaking is seen. ◎ Uneven wear is present.		
163	Valve	◎ Outer circumference is scored.		

7.3 TIGHTENING TORQUE

Tightening Torque Table

Part No.	Nomenclature	Screw size	Q' ty	Tightening torque	
19	Reamer bolt	M20 (P2.5)	3	37.6±4kgf·m	(272±29ft·lbs)
33	Socket head plug	PT 3/8	2	4±1kgf·m	(29±7ft·lbs)
121	Plug	M20 (P1.5)	1	6±1kgf·m	(43±7ft·lbs)
124	Plug	M30 (P1.5)	2	17±2kgf·m	(123±14ft·lbs)
126	Plug	M24 (P1.5)	2	9±1kgf·m	(65±7ft·lbs)
143	Socket head capscrew	M10 (P1.5)	8	5.9±1kgf·m	(43±7ft·lbs)
152	Socket head plug	PT 1/4	2	3±0.5kgf·m	(22±4ft·lbs)
160	Plug	M30 (P1.5)	1	17±2kgf·m	(123±14ft·lbs)
170	Socket head capscrew	M8 (P1.25)	4	3±0.5kgf·m	(22±4ft·lbs)

8. TROUBLESHOOTING

Motor does not start.	No pressure	Relief set press is low.	Set it correctly.
		Pump fails.	Check that motions other than travel are okay and remedy if out of order.
		Direction valve is out of order.	Check if spool is normal and repair if necessary.
	Pressure is okay.	Brake valve is out of order.	If spool or valve is seized, replace it. On other cases, repair.
		Hydraulic motor fails.	Replace motor or check hydraulic oil. If faulty, replace hydraulic oil.
		Gear (in reduction unit) is broken.	Replace motor with reduction unit.
		Motor is overloaded.	Eliminate load.
Oil leaks.	Through matching faces	Scratches on matching face	Correct surface with grindstone, emery paper, etc.
		Bolts loosened	Check after retightening
	From casing	Plug is loosened	Retighten
		Casing cracked by stone, stone, etc.	Replace motor with reduction unit.
	From floating seal	Sliding surface is worn.	Replace motor with reduction unit.
		Creep occurs to O rings.	Replace motor with reduction unit.
	From hydraulic motor	Bolts are loosened.	Retighten
		O ring is damaged.	Replace O ring.
		Seal face is scored.	Correct with grindstone, paper, etc.
Machine slides down on a slope.	Motor has poor volumetric efficiency.		Replace motor with reduction unit.
	Internal leakage from brake valve increased		Replace brake valve. (Replace rear flange.)
	Parking brake is not working.	Spring is broken.	Replace spring.
		Friction plate is worn.	Replace friction plate and companion plate.

Surface temperature of reduction unit casing is high.	Gear oil is short.		Refill to a proper level.
	Pitching occurs to bearing.		Replace motor with reduction unit.
	Hydraulic oil intruded into gear casing.		Replace oil seal.
Machine zigzags.	It occurs at low pressure.	Delivery rate differs on RH and LH motors.	Repair pump.
		Drain rate differs on RH and LH motors.	Replace motor with reduction unit.
	It occurs at high pressure.	Delivery rate differs on RH and LH motors.	Repair pump and regulator.
		Drain rate differs on RH and LH motors.	Replace motor with reduction unit.
		RH and LH brake valves moves differently.	Replace brake valve. (Replace rear flange.)
		Relief pressure of either the RH or LH control valve is low.	Set pressure to a correct level.
Speed does not go up.	The delivery rate of the pump is low.	The pump regulator does not work correctly.	Repair the regulator.
		The pump has a large amount of external leakage.	Repair or replace the pump.
	The motor has a large amount of leakage.		Replace motor with reduction unit.
Abnormal sound is heard.	Motor or reduction unit is broken.		Replace motor with reduction unit.
	Piping vibrates.		Clamp piping.

BooK code No. S5160116E

KOBELCO

SHOP MANUAL

SWIVEL JOINT

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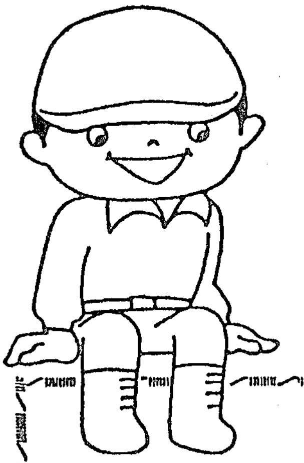
KOBE STEEL, LTD.



PREFACE

The swivel joint is installed in the center part of the rotating body and continuously maintains the connection of the fluid circuit regardless of the swing angle.
Major parts of this swivel joint consist of body and stem which are able to rotate reciprocally and each is provided with ports for the number of fluid circuit on it.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	June,1990	S5160116E K

1. SPECIFICATION

1.1 APPEARANCE AND PRINCIPAL PARTICULARS

1.1.1 SPEC-1 (STD)

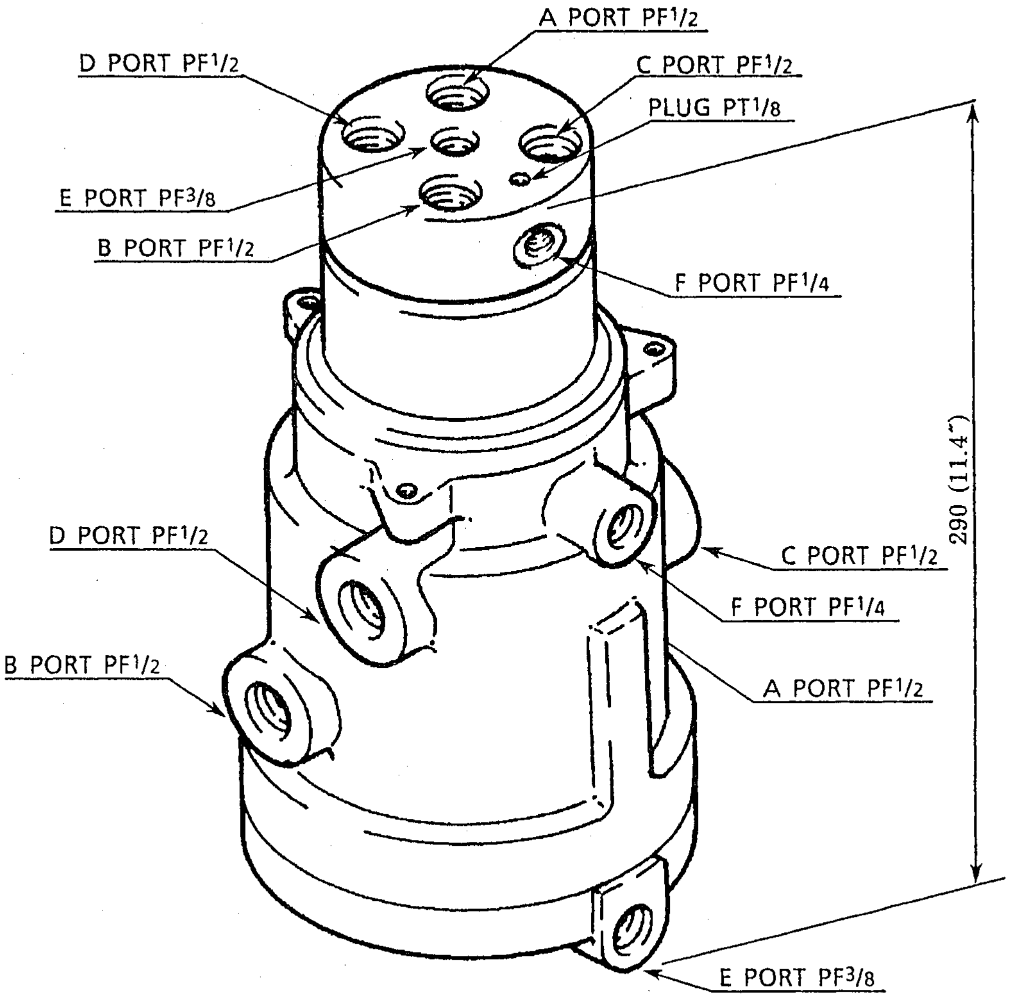

A PORT PF1/2
D PORT PF1/2
C PORT PF1/2
PLUG PT1/8
E PORT PF3/8
B PORT PF1/2
F PORT PF1/4
290 (11.4")
D PORT PF1/2
C PORT PF1/2
F PORT PF1/4
B PORT PF1/2
A PORT PF1/2
E PORT PF3/8

Fig. 1 Outside view of swivel joint

1.1.2 MAJOR SPECIFICATIONS

Table 1

High pressure ports A , B , C , D	Working pressure Max, impact pressure (pressure tightness)	260kgf/cm^2 (3700 psi) 390kgf/cm^2 (5550 psi)
Low pressure ports E	Working pressure	5kgf/cm^2 (71.1 psi)
Low pressure ports F	Working pressure	50kgf/cm^2 (711 psi)
Revolution		15rpm
Weight		18kg (40 lbs)

1.1.3 SPEC-1 (OPT : DOZER)

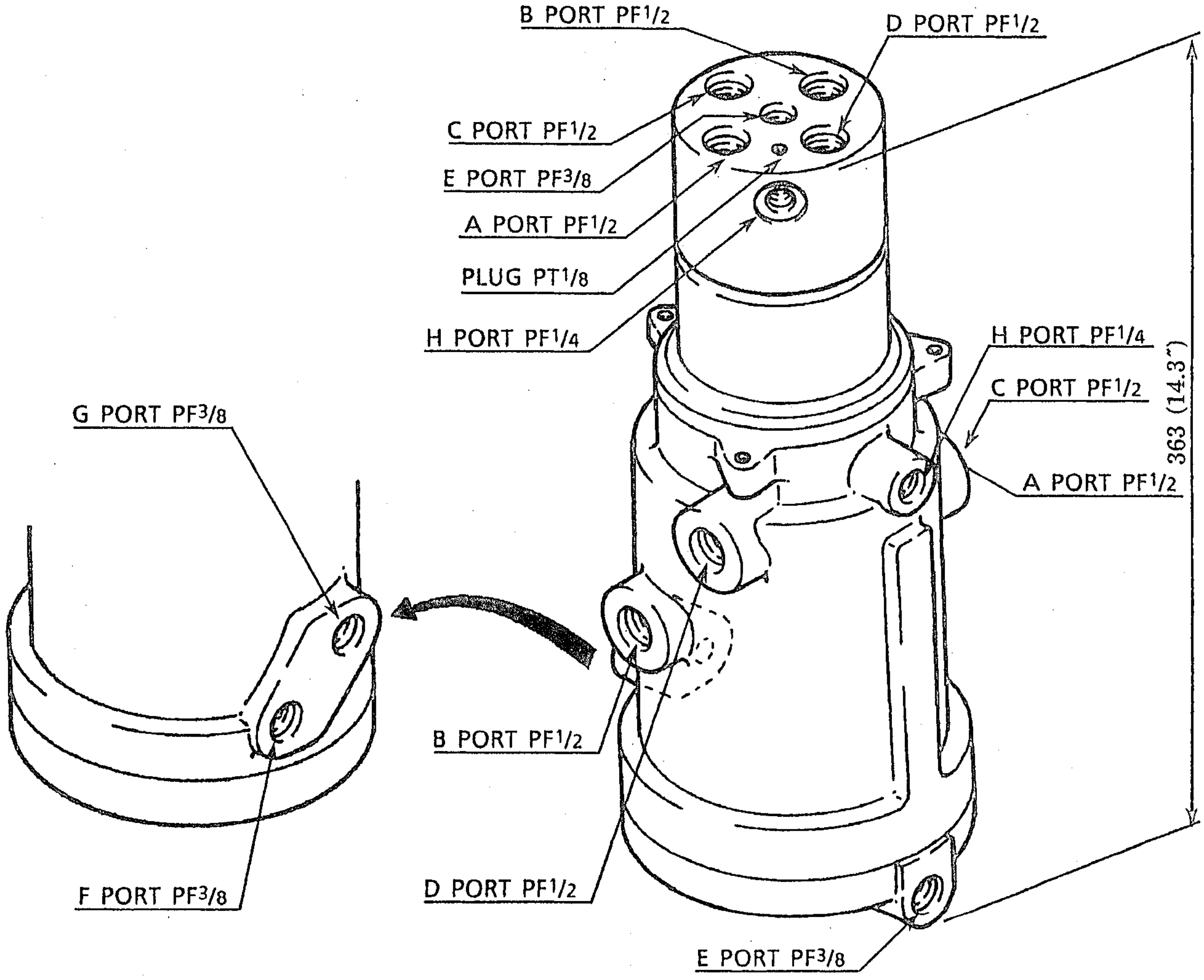

B PORT PF1/2
D PORT PF1/2
C PORT PF1/2
E PORT PF3/8
A PORT PF1/2
PLUG PT1/8
H PORT PF1/4
H PORT PF1/4
C PORT PF1/2
363 (14.3")
A PORT PF1/2
G PORT PF3/8
B PORT PF1/2
F PORT PF3/8
D PORT PF1/2
E PORT PF3/8

Fig. 2

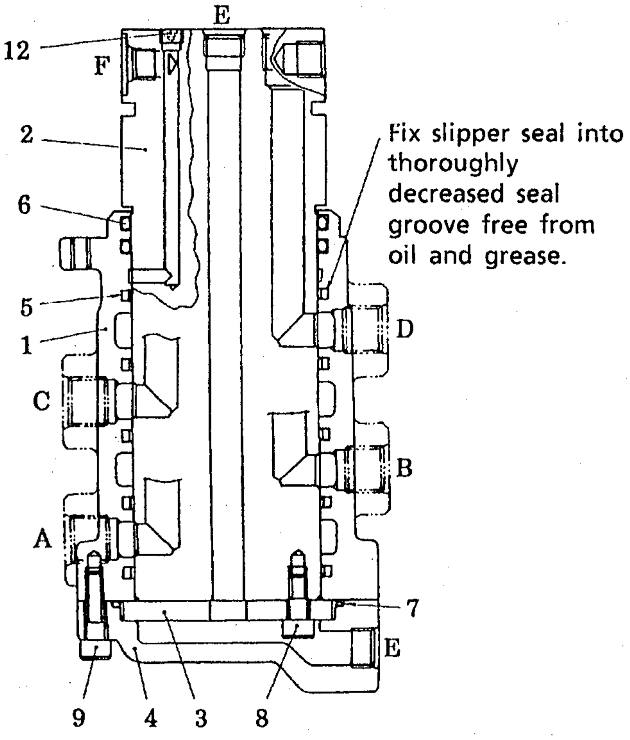
1.1.4 MAJOR SPECIFICATIONS

Table 2

High pressure ports A , B , C , D	Working pressure Max, impact pressure (pressure tightness)	260kgf/cm^2 (3700 psi) 390kgf/cm^2 (5550 psi)
High pressure ports F·G	Working pressure Max, impact pressure	210kgf/cm^2 (2990 psi) 390kgf/cm^2 (5550 psi)
Low pressure ports E	Working pressure	5kgf/cm^2 (71.1 psi)
Low pressure ports H	Working pressure	50kgf/cm^2 (711 psi)
Revolution		15rpm
Weight		21kg (46 lbs)

2. CONSTRUCTION AND FUNCTION

- Spec. 1



Fix slipper seal into thoroughly decreased seal groove free from oil and grease.

☞ Tightening torque 3.1kgf·m (22 lbs) (8 , 9)
Apply Locktite 290 to threads (the same Spec-2).

Fig. 3 Cross-sectional view of swivel joint

- Spec. 2

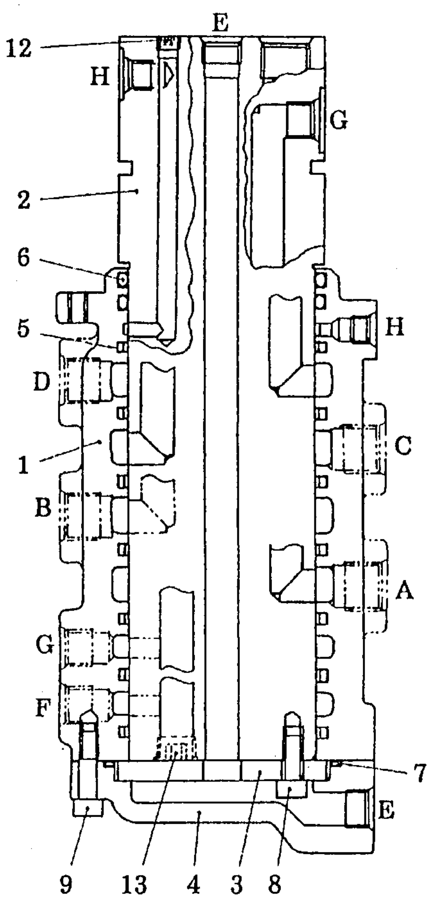


Fig. 4

Table 3

No.	NAME	Q'ty		No.	NAME	Q'ty	
		Spec.1	Spec.2			Spec.1	Spec.2
1	BODY	1	1	7	O RING	1	1
2	STEM	1	1	8	SOCKET BOLT	2	2
3	THRUST PLATE	1	1	9	SOCKET BOLT	3	3
4	COVER	1	1	12	PLUG	1	1
5	SEAL ASS'Y	5	7	13	PLUG	—	2
6	O RING	2	2				

☞ Let us explain Spec. 1 (STD) hereinunder :

Main portion of the swivel joint consists of body (1) which rotates freely, swivel stem (2), thrust plate (3) which prevents disconnection of body and stem, cover (4) which closes one side of swivel body (1), slipper seal sets (5), which divide circuits, and Orings (6,7), which prevent external oil leakage.

Four ports for the main circuits are provided on body (1) and stem (2), four oil passage grooves are machined on the inner face of the body (1), and seal sets (5) are provided at top and bottom of circumferential grooves.

Body (1) and stem (2) rotate freely. Oil from body (1) or stem (2) flows into stem (2) or body (1) through circumferential grooves between body (1) and stem (2) ; Oil flow is thus not obstructed by swiveling. Lubricating oil groove to drain port is also provided to prevent seizure of body (1) or stem (2) by swiveling.

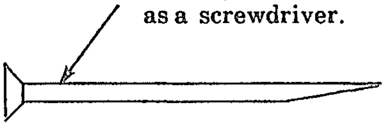
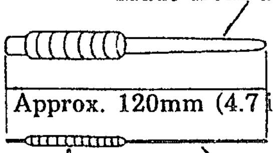
With this construction, swivel joint assures circuit connection between the lower body and the revolving upper body.

3. DISASSEMBLY AND ASSEMBLY

3.1 PREPARATION

3.1.1 TOOLS

Table 4

Symbol	Tool Name	Used for	Remarks
a	Hammer	Disassembly Assembly	1. Steel hammer 2. Wooden or plastic hammer
b	Rubber mat		Not less than 500mm (1 ft 7.7 in) square
c	Wrench		1. Allen wrench 2. Double-ended and single-ended wrench 3. Extension pipe
d	Torque wrench	Assembly	10kgf·m (70 ft·lbs)
e	Pin	Disassembly	Grind the tip of "a nail" to shape as a screwdriver. 
f	Spatula	Disassembly Assembly	Made from a hacksaw blade  Approx. 120mm (4.7 in) Vinyl tape Remove the edge completely and make corner round smooth.
g	Vise	Disassembly Assembly	Vises movable over 150mm (5.9in)
h	Locktite		#290
i	Lubricating oil		Hydraulic oil or vaseline
j	Cleaning oil		

3.1.2 APPARATUS

(1) Hoist or crane

The lifting device should be capable of lifting the swivel joint assembly.

(2) Work bench

The work bench should have an area of 1.2m× 1.5m (3 ft 11.2 in× 4 ft 11 in).

(3) Others

Also prepare waste cloth, wooden block and oil pan.

3.1.3 CLEANING OUTSIDE

Clean outside of the removed swivel joint with water or steam.

☞ Clean swivel joint with their ports plugged up.

3.2 DISASSEMBLY

The part numbers used in this disassembly procedure correspond to those of a construction drawing in Fig. 2.

Let us explain Spec. 1 (STD) hereinunder:

3.2.1 DISMANTLING COVER

1) Place a V-block on a work bench, mount a swivel joint set on the side, fix it and loosen capscrew (9) by means of a allen key wrench.

☞ • Mark cover (4) and body (1) with matching marks for convenient re-assembly.

• Alternately, the swivel joint may be fixed by holding stem (2) in a vise.

2) Remove cover (4) from body (1) and draw out O ring (7) from cover (4).

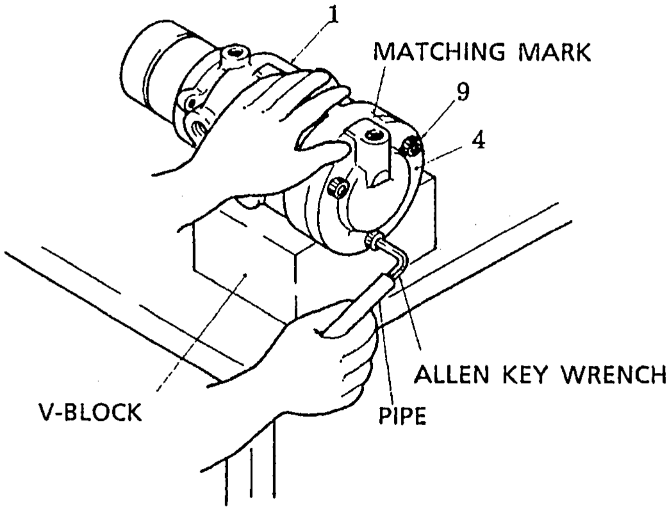

1
MATCHING MARK
9
4
ALLEN KEY WRENCH
V-BLOCK
PIPE

Fig. 5 Removing cover (4)

3.2.2 DISMANTLING THRUST PLATE

Loosen capscrew (8) fastening thrust plate (3), in the same manner as the dismantling of the above-mentioned cover.

☞ When dismantling thrust plate (3) by fixing body (1), support stem (2) so it may not fall down.

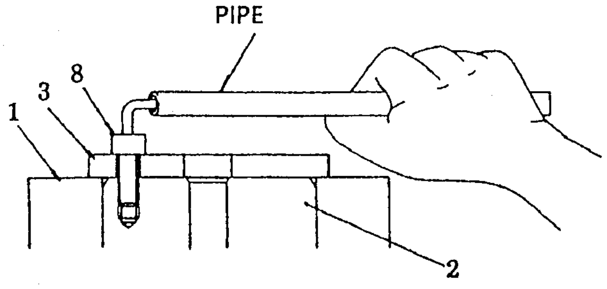


Fig. 6 Removing thrust plate (3)

3.2.3 EXTRACTION OF STEM

Place body (1) on a V-block and knock stem (2) till about half of the stem sticks above the body. By hitting out the stem over about 1/2 from the body, it can be easily pulled out.

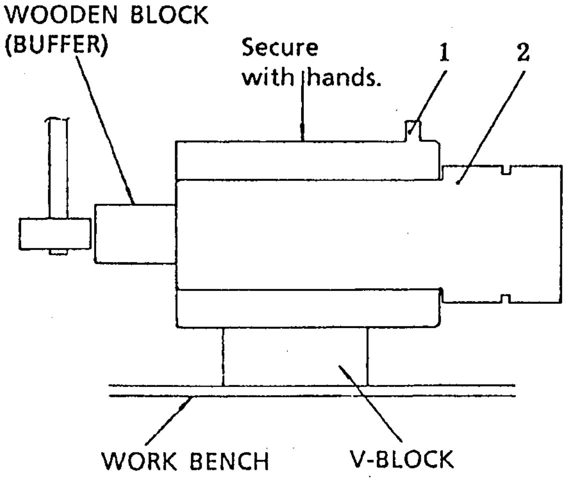

WOODEN BLOCK
(BUFFER)
Secure
with hands.
1
2
WORK BENCH
V-BLOCK

Fig. 7 Drawing out stem (2)

3.2.4 REMOVING SEALS

1) Pull out O ring (6) from the O ring groove with the aid of a spatula.

☞ Use the tip of the spatula taking not to mar the body. Also do not strike the spatula.

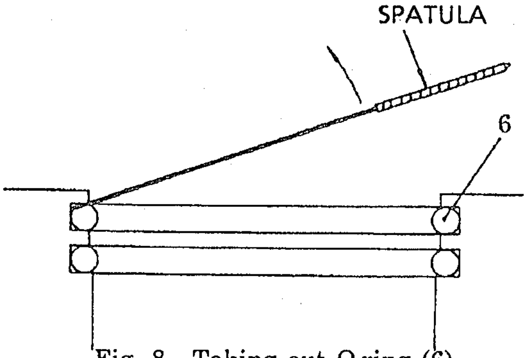


Fig. 8 Taking out O ring (6)

2) Pierce pin (e) to seal (5) and extract slipper ring (5). Fig.9 shows the use of one pin, but by using two pins, this can be extracted with more sureness.
As the backup ring is of rubber substance, remove this in the same procedure as O ring (6).

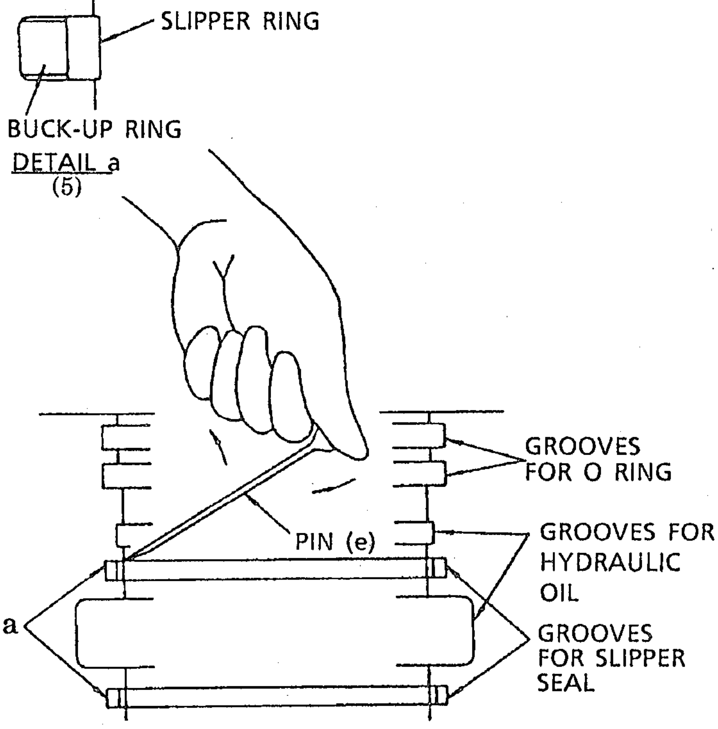


Fig. 9 Taking out seal ass'y (5)

3.3 ASSEMBLY

Prior to assembly, clean each parts (excluding the O ring and slipper ring), and arrange in the sequence of assembly.

3.3.1 ASSEMBLING SEALS TO BODY

1) Coat O ring (6) lightly with vaseline (or hydraulic oil) and install in the O ring groove. Also make sure that the O ring in not distorted after installation.
2) Slipper ring is assembled, after first inserting the backup ring, by slightly-changing the shape as shown in Fig.8. Also after inserting all of the seals, be certain that these are installed in the seal groove by use of the spatula.

☞ When assembling the slipper ring, make sure that oiliness, such as vaseline, hydraulic oil and grease, has been completely removed.

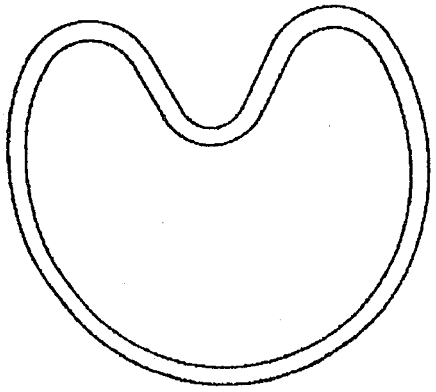


Fig. 10 Inserting seal ass'y (5)

3.3.2 ASSEMBLING STEM

Lightly coat the outer circumference of stem (2) and the inner surface of body (1) with grease or vaseline and slowly insert stem (2) into body (1).

☞ It stem (2) is pressed in too fast, the seal may be damaged. Do it slowly. The clearance between body (1) and stem (2) is about 0.1mm (0.0039in). Erect stem straight along the shaft center.

Press in by applying your weight by your both hands.

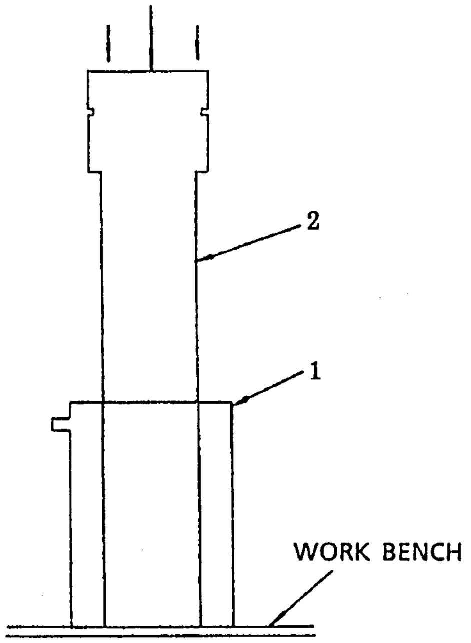


Fig. 11 Inserting stem (2)

3.3.3 ASSEMBLING THRUST PLATE

1) While holding stem (2) and body (1), match the hole of thrust plate (3) and the stem (2) hole.
2) Next, after removing any oil from the thread part of socket bolt (8). coat it with locktite #290 and tighten to the torque of 3.1 ± 0.3 kgf·m (22±2 ft·lbs) to stem (2).

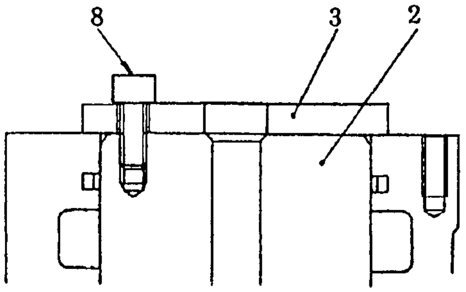


Fig. 12 Tightening socket bolt (8)

3.3.4 ASSEMBLING COVER

After installing O ring (7) to cover (4) and aligning the matching marks of the cover (4) and body (1), tighten socket bolt (9) to the torque of 3.1±0.3kgf·m (22±2 ft·lbs) which will then complete assembly.

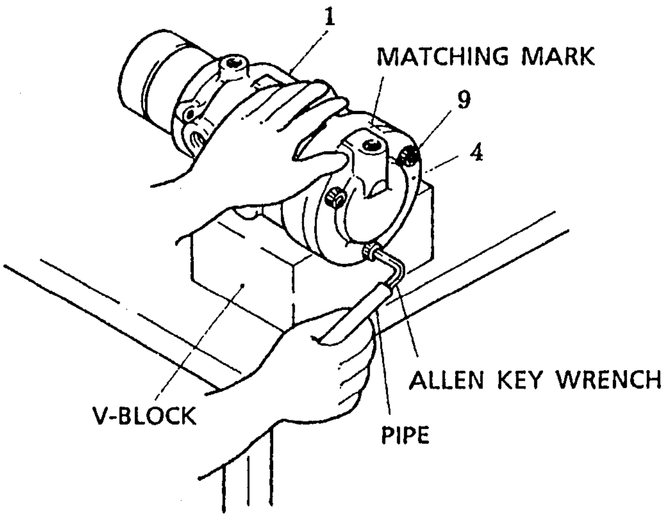


Fig. 13 Tightening socket bolt (9)

4. MAINTENANCE STANDARDS

4.1 INSPECTION PROCEDURE AND REMEDY

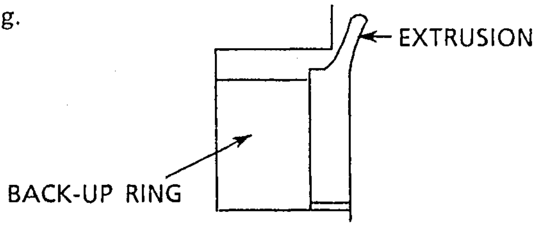
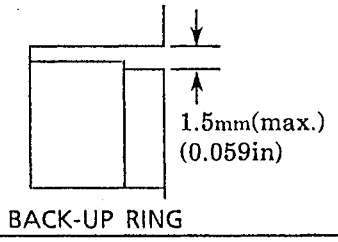
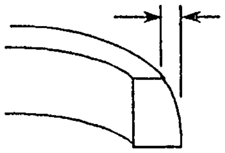
Table 5

Interval	Check Item	Checking Procedure	Remedy
2,000Hrs.	Seal for oil leakage outside	Check oil leakage outside	Replace O ring, if any oil leakage can be found.
4,000Hrs. In principle, disassemble and check regardless of oil leakage or not.	All sealing parts		Replace all sealing parts such as slipper seal with square seal and O ring.
	All rubbing parts	Check abnormal wear, scoring or corrosion caused by foreign particles or burning.	Repair or replace referring to their limit of serviceability.
When disassembled for repair	All parts	Check them for burning, foreign particles, abnormal wear, and defect of seals.	Repair or replace referring to their limit of serviceability. O rings should be replaced.

4.2 USABLE LIMIT OF THE PARTS

Table 6

Parts		Maintenance Standards	Remedy
Body, Stem	Sliding surface with sealing sections	Plating worn or peeled due to seizure or contamination.	Replace
	Sliding surface between body and stem other than sealing sections	1) Worn abnormality or damaged more than 0.1mm (0.0039in) in depth due to seizure contamination.	Replace
		2) Damaged more than 0.1mm (0.0039in) in depth.	Smooth with oilstone.
	Sliding surface with thrust plate	1) Worn more than 0.5mm (0.02in) or abnormality.	Replace
		2) Worn less than 0.5mm (0.02in).	Smooth
		3) Damage due to seizure or contamination remediable within wear limit (0.5mm) (0.02in).	Smooth
Cover	Sliding surface with thrust plate	1) Worn more than 0.5mm (0.02in) or abnormality.	Replace
		2) Worn less than 0.5mm (0.02in).	Smooth
		3) Damage due to seizure or contamination remediable within wear limit (0.5mm) (0.02in).	Smooth

Parts		Maintenance Standards	Remedy
Slipper ring		1) Extruded excessively from seal groove square ring.  EXTRUSION BACK-UP RING	Replace (With back-up ring)
		2) Slipper ring 1.5mm (0.059in) narrower than seal groove, or narrower than back ring.  1.5mm(max.) (0.059in) BACK-UP RING	Replace (With back-up ring)
		3) Worn more than 0.5mm (0.02 in) 	Replace (With back-up ring)

4.3 INSPECTION AFTER ASSEMBLY

After completion of assembly, inspection for oil leakage, pressure resistance, etc., using a device as shown in the figure below.

(1) High pressure port

Install a changeover valve and pressure gauge to the stem side port and body side port respectively, and while watching the pressure gauge (for high pressure) installed on the body side and also by regulating high pressure relief valve (7), gradually increase the pressure and when the pressure has reached 1.5 times the maximum working pressure, close stop valve (3) and lock in the hydraulic oil in the swivel. Keep stop valve (6) on the low pressure relief valve side closed at this time.

(2) Low pressure port

(Drain port, return port, etc.)

Similar to the high pressure port, install a changeover valve and pressure gauge on each port of the stem side and body side.

Open stop valve (6) on the side of low pressure relief valve (5) and while watching the pressure gauge (for low pressure) connected to the body side and also by regulating low pressure relief valve (5), gradually increase the pressure and check for outside leakage with a color check at a pressure of 5 kgf/cm^2 (71 lbs / in^2).

☞ What is called "maximum working pressure" here is the pressure of the hydraulic excavator to which a swivel joint is mounted.

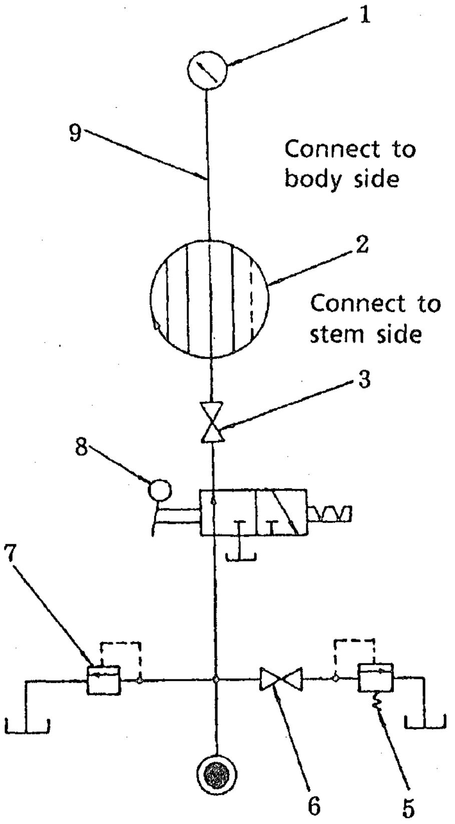


Fig. 14 Hydraulic circuit for inspection equipment

Table 5

Item	Description	Remarks
1	Pressure Gauge	High and Low Pressures are required.
2	Swivel Joint	
3	Stop Valve	
5	Relief Valve for low pressure	Setting Pressure : 5kgf/cm^2 (71 lbs/in^2)
6	Stop Valve	
7	Relief Valve for high pressure	Setting Pressure : (Max. working pressure 260kgf/cm^2×1.5 times)
8	Changeover Valve	
9	Piping, etc.	

5. TROUBLESHOOTING

Table 8

Trouble	Cause	Remedy
1. External leakage of hydraulic fluid	Defective O ring	Replace all seals.
2. Internal leakage of hydraulic fluid	1) Defective slipper seal 2) Sliding face worn excessively	1) Replace all seals. 2) Replace ass'y.
3. Swivel joint seized	1) Stem and body seized 2) Inappropriate swivel stopper bracket	1) Grind and hone. Replace assembly, if stem and body are too loose and causing oil leakage. 2) Reinstall Secure 2~3mm (0.08~0.1in) allowance for bolt stopper.
4. Loose swivel stem and cover	Socket bolt tightened insufficiently.	Retighten.

BooK code No. S5 17014 5E

KOBELCO

SHOP MANUAL

HYDRAURIC CYLINDER (0.3m³H.sh)

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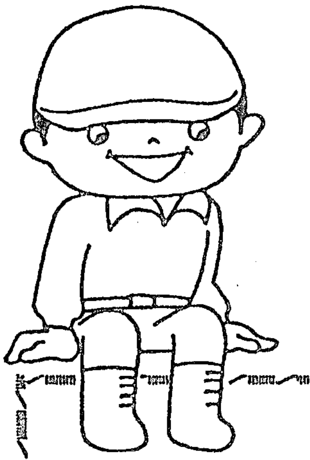
KOBE STEEL, LTD.



PREFACE

Hydraulic cylinders are equipments that convert the energy of the pressurized oil fed by the pump to reciprocating motions. The cylinder is composed of a rod cover, cylinder tube, piston rod and others. Hydraulic cylinders vary in the piston diameter, rod diameter, stroke, sealing method and cylinder bearing method, depending upon their service conditions, but are identical in terms of fundamental construction.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	June, 1990	S5170145E K

1. SPECIFICATION

1.1 GENERAL VIEW

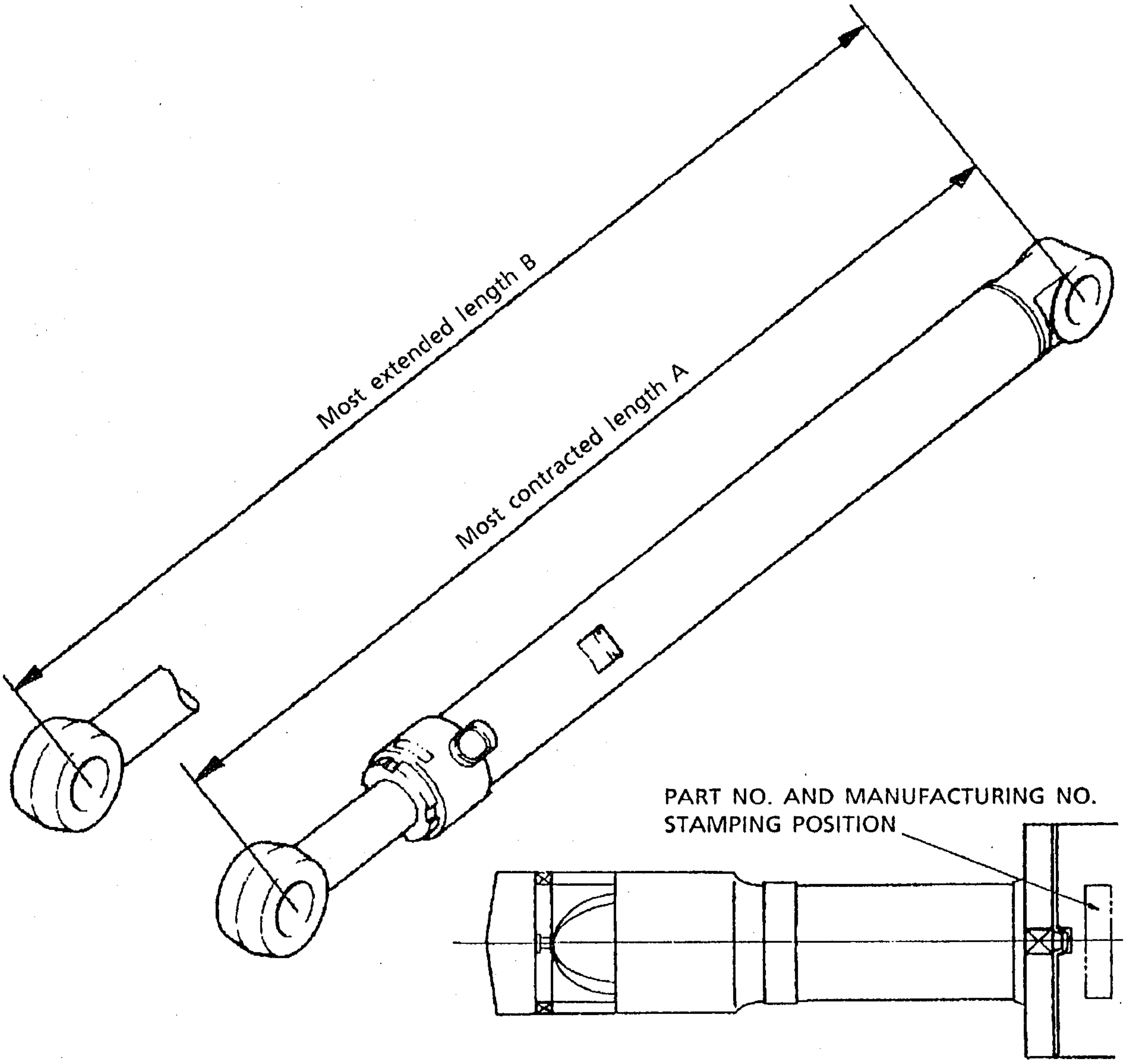

Most extended length B
Most contracted length A
PART NO. AND MANUFACTURING NO.
STAMPING POSITION

Fig. 1 Outside view of cylinder

1.2 MAJOR SPECIFICATIONS

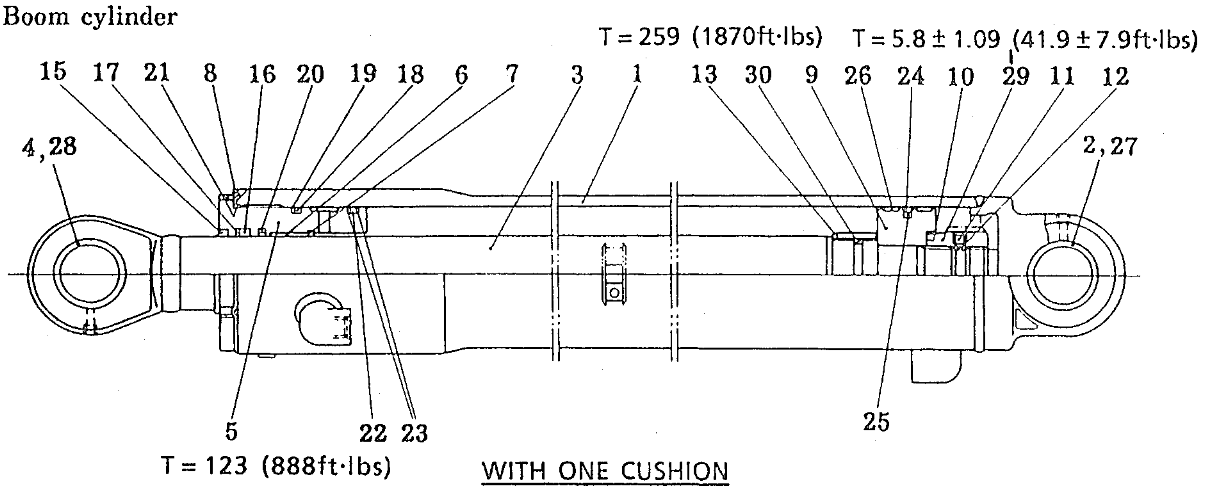
Table 1 Unit: mm (ft-in)

Cylinder	Cylinder bore / Rod Dia.	Stroke	Center-to-Center Distance of Pins Full extended B / Full contracted A	Cushion	Dry weight kg (lbs)
Boom	125 / 70 (4.92″/ 2.76″)	940 (37.0″)	2305/ 1365 (7′6.7″ / 4′5.7″)	yes	110 (243)
Arm	110 / 65 (4.33″ / 2.56″)	900 (35.4″)	2245 / 1345 (7′4.4″ / 4′5″)	yes	87 (192)
Bucket	95 / 60 (3.74″ / 2.36″)	725 (28.5″)	1835 / 1110 (6′0.2″ / 3′7.7″)	No	58 (128)

2. CONSTRUCTION AND FUNCTION

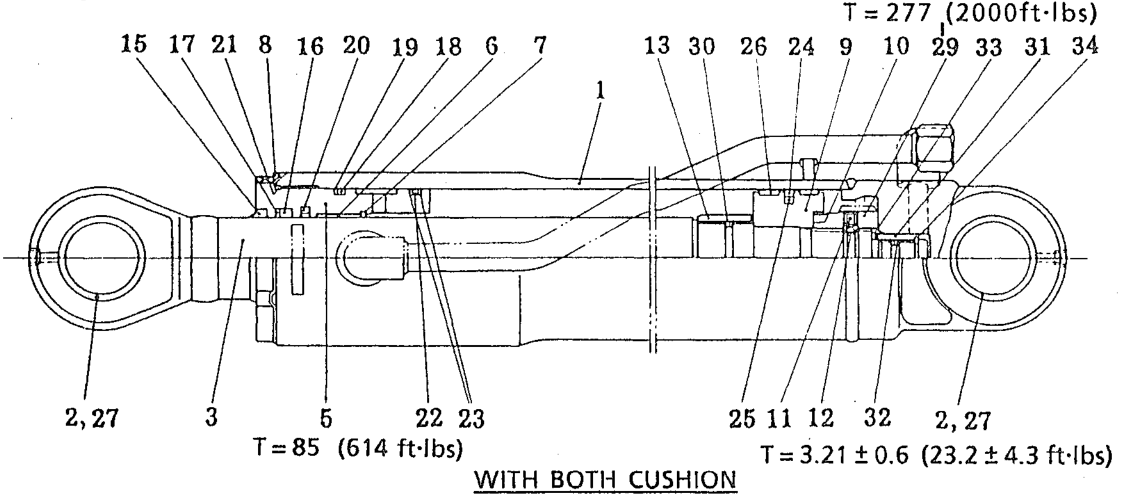
2.1 CONSTRUCTION

Boom cylinder



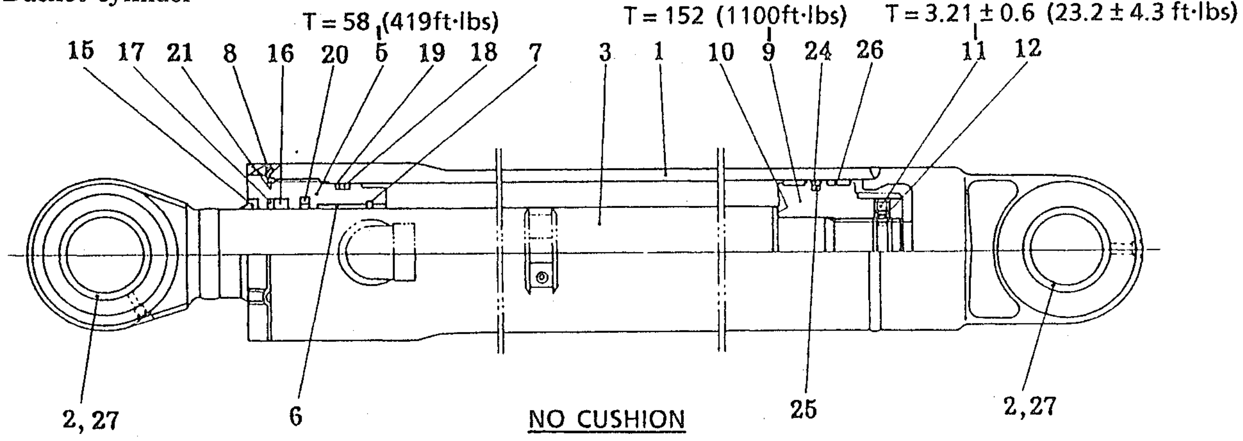
T = 259 (1870ft·lbs)
T = 5.8 ± 1.09 (41.9 ± 7.9ft·lbs)
15 17 21 8 16 20 19 18 6 7 3 1 13 30 9 26 24 10 29 11 12
4,28
2,27
5 22 23
25
T = 123 (888ft·lbs)
WITH ONE CUSHION

Arm cylinder



T = 277 (2000ft·lbs)
15 17 21 8 16 20 19 18 6 7
1
13 30 26 24 9 10 29 33 31 34
2,27 3 5 22 23
T = 85 (614 ft·lbs)
25 11 12 32 2,27
T = 3.21 ± 0.6 (23.2 ± 4.3 ft·lbs)
WITH BOTH CUSHION

Bucket cylinder



T = 58 (419ft·lbs)
T = 152 (1100ft·lbs)
T = 3.21 ± 0.6 (23.2 ± 4.3 ft·lbs)
15 17 21 8 16 20 5 19 18 7 3 1 10 9 24 26 11 12
2,27
6
NO CUSHION
25
2,27

Fig. 2 Cross-sectional view of cylinder

☞ Coat the thread of the cylinder head with Three Bond 1901 (or equivalent).

☞ Tightening torque T=kgf·m (Unit)

Table 2

NO.	NAME	Quantity		
		Boom Cyl.	Arm Cyl.	Bucket Cyl.
1	CYLINDER TUBE	1	1	1
2	PIN BUSHING	2	2	2
3	PISTON ROD	1	1	1
4	PIN BUSHING	1	–	–
5	ROD COVER	1	1	1
6	BUSHING	1	1	1
7	SNAP RING	1	1	1
8	LOCK WASHER	1	1	1
9	PISTON	1	1	1
10	SHIM	1	1	1
11	SETSCREW	1	1	1
12	BALL	1	1	1
13	CUSHION BEARING	1	1	–
15	WIPER RING	1	1	1
16	U RING	1	1	1
17	BACKUP RING	1	1	1
18	O RING	1	1	1
19	BACKUP RING	1	1	1
20	BUFFER RING	1	1	1
21	O RING	1	1	1
22	O RING	1	1	–
23	BACKUP RING	2	2	–
24	SEAL RING	1	1	1
25	O RING	1	1	1
26	SLIDE RING	2	2	2
27	WIPER RING	2	4	4
28	WIPER RING	2	–	–
29	NUT	1	1	–
30	CUSHION SEAL	1	1	–
31	CUSHION BEARING	–	1	–
32	CUSHION SEAL	–	1	–
33	SNAP RING	–	1	–
34	STOPPER	–	2	–

The hydraulic cylinder consists mainly of cylinder tube (1). piston (9) reciprocating in it, piston rod (3) taking cut the piston movement, and rod cover (5) acting as a lid and a guide. Cylinder tube (1) and piston rod (3) are provided with a pinmounting part (clevis), a trunnion or a flange for connection with other component.

Aside from these major parts, packings, seals or bushings are provided on the sliding areas between piston (9) and cylinder tube (1) piston rod (3) and rod cover (5) or cylinder tube (1) and rod cover (5).

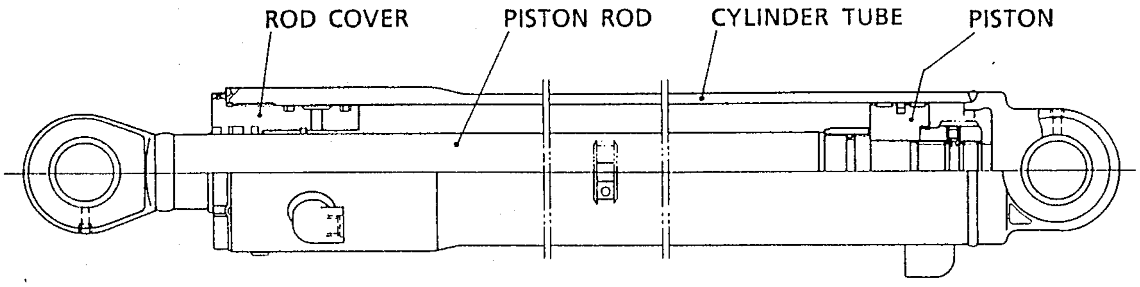


Fig. 3

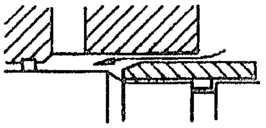
2.2 FUNCTION

If pressurized oil is fed alternatively to the oil inlet and outlet provided in the cylinder, force acts on the piston which in turn causes the piston rod (3) to extend and retract.

Impact occurs when the moving piston (9) of the cylinder with cushion bumps directly against rod cover (5). A cushioning means as shown in Fig. 4 is provided to damp the impact.

Before piston (9) hits rod cover (5), cushion bearing (13) thrusts into the head. As the result the oil in chamber A formed by cushion bearing (13) and piston (9) runs through the clearance over the outer circumference of cushion bearing (13). On that occasion, the motion speed of piston (9) is slowed down. Piston (9) then comes in comes in contact with rod cover (5), when the piston ceases to move.

If you push and pull swiftly and continuously from this stopped condition, the cushioning mechanism does not work as chamber A is not formed between piston (9) and cushion bearing (13). To let the cushion cylinder as it is intended for, manipulation must be done with such time allowance that permits chamber A to be formed.



DETAIL B

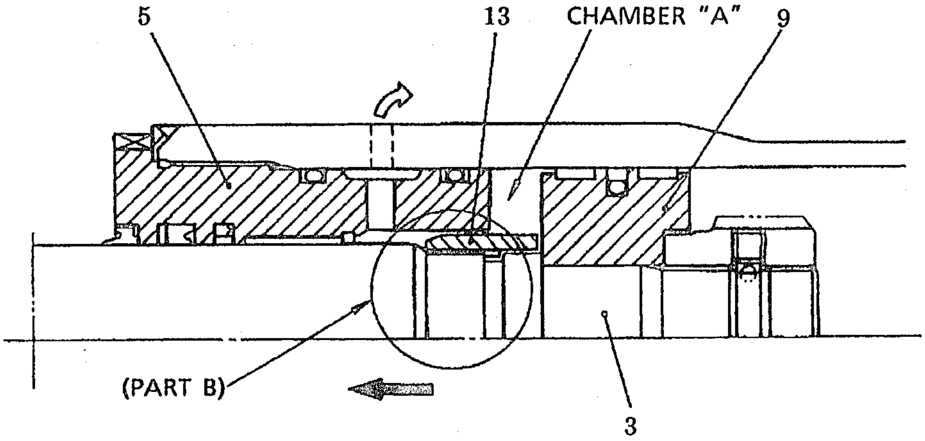


FIG. 4

3. DISASSEMBLY AND ASSEMBLY

3.1 PREPARATION BEFORE DISASSEMBLY

Before disassembly, it is necessary to keep a dustfree workshop and facilities.

3.1.1 WORK AREA

The following working area is required for disassembly:

(1) Ample space
For disassembly of the hydraulic cylinder, the cylinder tube and the piston rod must be extracted.
Therefore, the first prerequisite is that the working area must have sufficient space for such work. It is also necessary that the space have amply space widthwise to accommodate disassembly, cleaning and measuring facilities.

(2) Suitable working environment
The hydraulic cylinder is a precision-machined product incorporating seals and packings made of rubber and plastic materials. For this reason, care should be used so that the hydraulic cylinder is free from dust, dirt, sand, metal chips, weld slag and other hard substance. If the hydraulic cylinder is assembled without being aware of hard particles stuck on the cylinder tube and the piston rod, the tube inner surface and the rod surface may be scratched as the cylinder operates, thereby disabling it in worst cases. Damage to the piston seals and the rod seals will result in oil leaks. For this reason, grinding and welding operation should be avoided near the working area to keep it clean.

3.1.2 APPARATUS

The following equipment are required for disassembly:

(1) Hoist or crane
The hoist or the crane must be capable of carrying the cylinder in an assembled condition. It must also be capable of making level and linear movement under load for inserting and extracting the piston rod and the tube.

(2) Work bench
The work bench must have strength and rigidity capable of accommodating the total length of the cylinder in its most retracted condition and of with-standing the repulsive force of the tightening torques of the cylinder head and the piston nut. Since a vise is attached to the bench, the width of the work bench must be sufficiently large.

(3) Support stand
If the clevis part of the piston rod is fully extended in a free condition, the bushing and the seals may be damaged as the rod bushing and the piston are twisted due to the weight of the rod. A stand is required to support the rod to prevent such.

(4) Hydraulic source
A hydraulic source is required for disassembly and assembly of the cylinder head and the piston nut and for oil leak tests after completion of assembly.

(5) Jet air source
It is used for drying after oil draining and cleaning of the cylinder.

(6) Cleaning bath, cleaning oil and detergent

(7) Oil pan and oil reservoir
An oil pan is necessary to contain oil drained from the cylinder and oil spilt during work. An oil reservoir is required to collect oil spilt on the floor and waste oil.

(8) Others
Oil extracting hoses, wooden skids, rag and sawdust in which oil is soaked are also necessary.

3.1.3 NECESSARY TOOLS

Tools and jigs differ with types of cylinders, but it is necessary to prepare the tools in Table 3 as a guideline.

Table 3 List of Tools and jigs

Tool / Jig	Remarks	Tool / Jig	Remarks
Hammer	1. Steel hammer	Spatula	Metallic one with smooth corners.
	2. Wooden or plastic mallet	Gimlet	A sharp-point tool may be used in place of a gimlet.
Screwdriver	A few types of large and small sizes	Jig	1. For fitting seal rings
Chisel	Flat chisel		2. For pressing bushes
Vise	One having an opening wide enough to hold cylinder head O.D. and tube mounting pins (clevis).		3. For pressing wiper rings 4. For correcting seal rings 5. For inserting pistons
		Rust remover	
Wrench	1. Hook wrench 2. Double ended and single ended wrenches 3. Extension pipe for wrenches 4. Eye wrench for piston	Measuring instruments	1. Slide calipers 2. Micrometer 3. Cylinder gauge (Fig. 5) 4. V-block 5. Dial indicator

3.1.4 EXTERNAL CLEANING

The cylinder taken off the excavator has dust and foreign matter, and grease is usually adhered to the clevis part. For this reason, remove external soil and contamination from the cylinder with water and steam before bringing it into the workshop.

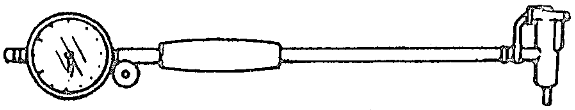


Fig. 5 Cylinder Gauge

☞ The cylinder described below is of the cushion-attached type. However, check the construction of the cylinder with the parts catalogue when disassembling and servicing the cylinder.

3.1.5 DISCHARGING OIL

Place a wooden-block on the work bench and mount the cylinder on it to prevent it from rotating. Charge air into ports A and B alternately to actuate the piston rod till the hydraulic oil in the cylinder is drained out. At this time, connect a suitable hose to each port so that the hydraulic oil may not gush out.

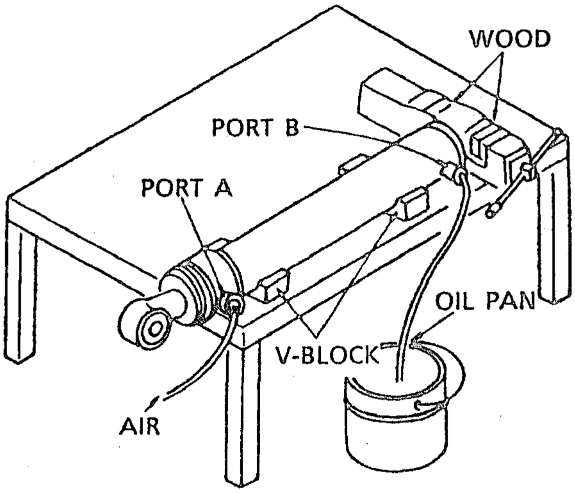


Fig. 6 Discharging Oil

3.2 DISASSEMBLY

☞ • When disassembling and servicing the cylinder, check the construction and the availability of service parts as well as necessary tools and jigs on separate parts catalog.

• The figures in parentheses after part names correspond to those in Fig. 2.

• The following explanatory drawings and quantities are for the arm cylinder. Do the same thing for other cylinders.

3.2.1 REMOVING CYLINDER HEAD AND PISTON ROD

1) Hold the levis section of the tube in a vise.

☞ Use mouth pieces so as not to damage the machined surface of the cylinder tube (1).
Do not make use of the outside piping as a locking means.

2) Pull out piston rod (3) about 200mm (7.9in). Because the piston rod (3) is rather heavy, finish extending it with air pressure after the above-mentioned oil draining operation.

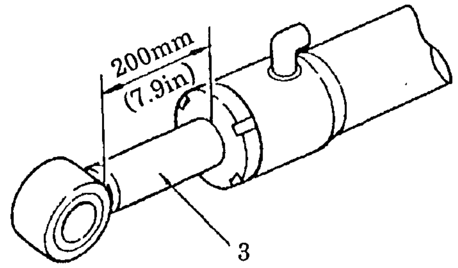

200mm
(7.9in)
3

Fig. 7 Drawing out the piston rod by 200mm (7.9in)

3) Straighten the folded part of lock washer (8) located between rod cover (5) and cylinder tube (1), using a chisel and a hammer. Do the same thing both on rod cover (5) and tube (1).

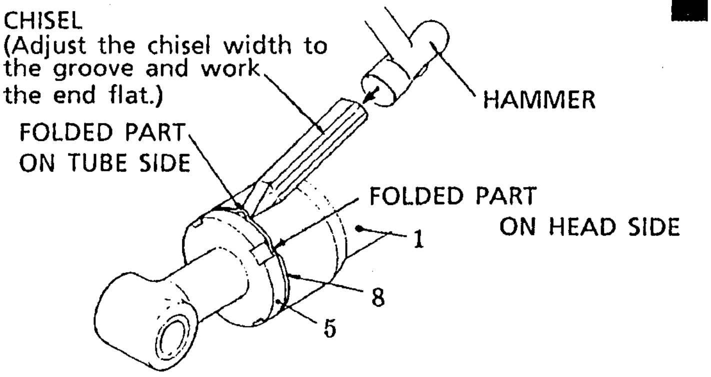

CHISEL
(Adjust the chisel width to the groove and work the end flat.)
HAMMER
FOLDED PART ON TUBE SIDE
FOLDED PART ON HEAD SIDE
1
8
5

Fig. 8

4) Then turn rod cover (5) counterclockwise till cylinder head (5) is disengaged from cylinder tube (1).

☞ • Do not heat the screwed part by gas in any circumstances to loosen the screw. Heating will distort the cylinder to an extent that interferes the cylinder with the piston, ultimately making it unserviceable.

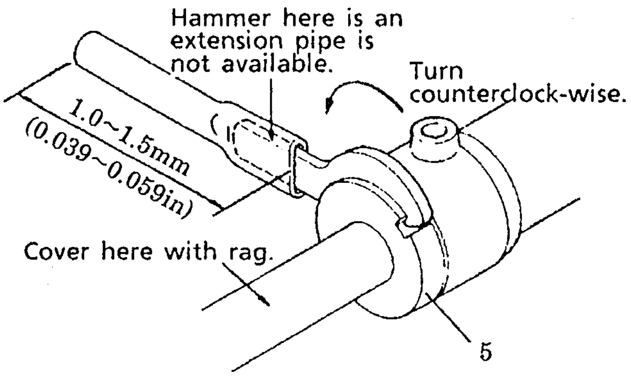

Hammer here is an extension pipe is not available.
Turn counterclock-wise.
1.0~1.5mm
(0.039~0.059in)
Cover here with rag.
5

Fig. 9

☞ ◎ If you use a hook wrench, use one that permits its claw to catch the notch of the nut and that has the radius of the roundness inside the wrench slightly smaller than the radium of the periphery of the nut. (Fig. 10a) This is important to determine the fulcrum of the wrench. Inversely, if the radius of the roundness of the wrench is larger, you can not fix a fulcrum and the catching part of the wrench tends to come off. In such a case, you can fix a fulcrum by putting a suitable iron piece, but you have to make certain that the contact of the catching part is sufficient. Fix the iron piece to the wrench by tack welding. (Fig. 10b)

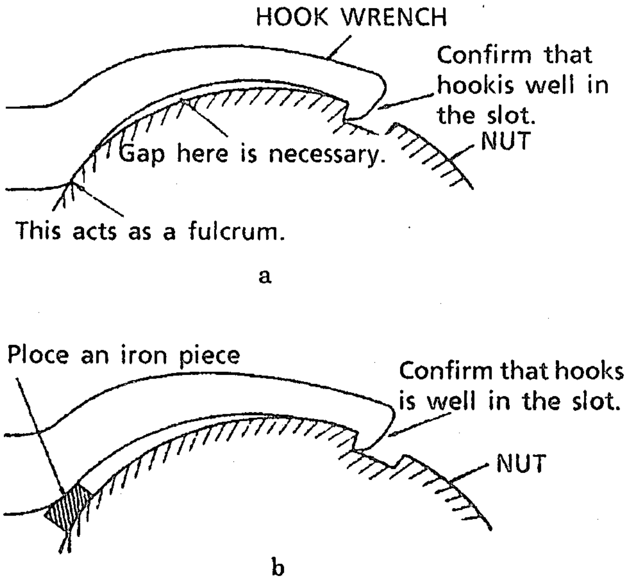

HOOK WRENCH
Confirm that hookis well in the slot.
NUT
Gap here is necessary.
This acts as a fulcrum.
a
Ploce an iron piece
Confirm that hooks is well in the slot.
NUT
b

Fig. 10

5) After making fully sure that engagement is off, strike the end face of rod cover (5) by means of a plastic mallet till rod cover (5) is drawn out. (In that case, the weight of piston rod (3) is exerted upon rod cover (5). Therefore, lift the tip of piston rod (3) by means of a crane so only the weight of the rod is held.)

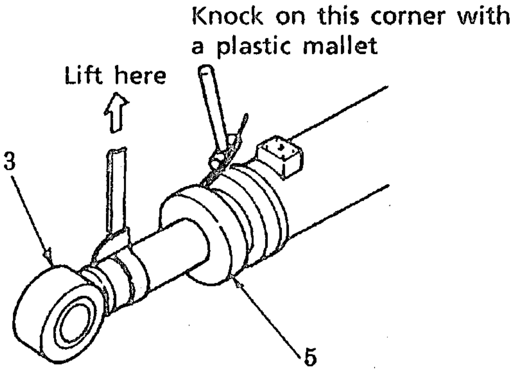

Knock on this corner with a plastic mallet
Lift here
3
5

Fig. 11

6) If you draw out cylinder head (5) from tube (1), the cylinder head falls down by the weight of the rod, so the rod and the thread may be damaged. Therefore, fix cylinder tube (1) on a proper bench and support the weight of the rod by lifting it as in Fig. 12. This will promote turning of the screw and thus ease operation.

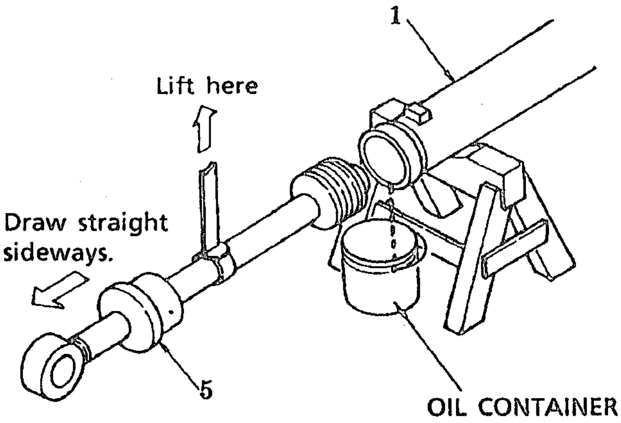

1
Lift here
Draw straight sideways.
5
OIL CONTAINER

Fig. 12

7) Place the removed piston rod ass'y on a wooden V-block that is set level.

☞ Cover a v-block with soft rag.

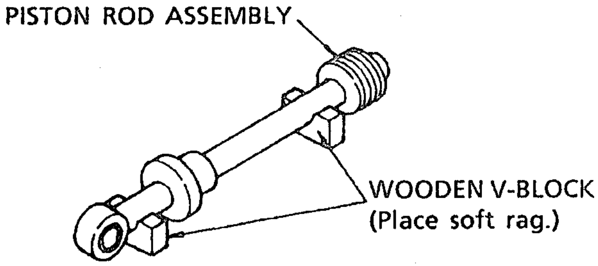

PISTON ROD ASSEMBLY
WOODEN V-BLOCK
(Place soft rag.)

Fig. 13

3.2.2 REMOVING PISTON ASSEMBLY

1) Fix piston rod (3) by holding its clevis section in a vise.

☞ Since piston (9) is tightened to large torque, it is necessary to place a proper support near the piston. When using a V-block, cover it with a soft cloth or something.

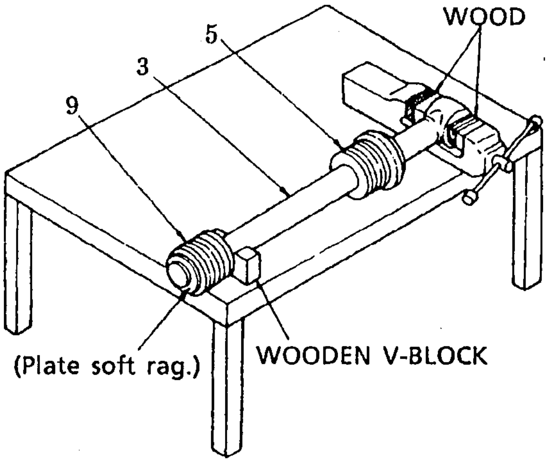


Fig. 14

2) Separate piston (9) from piston rod (3).
3) Loosen and remove the nut of piston (9), using a hexagon box wrench or an eye wrench fitted with an extension pipe. Loosening needs 1.5 time a specified torque and use of a power wrench that utilizes a hydraulic cylinder promotes operation.

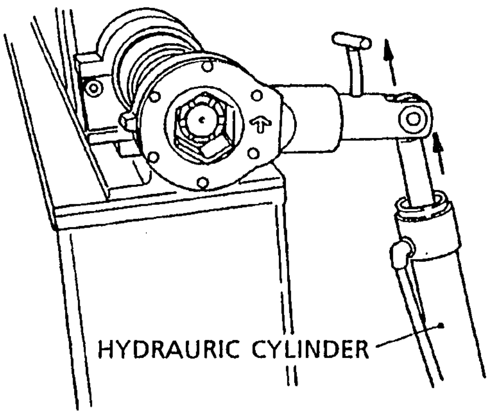


Fig. 15 How to loosen piston nut (9)

4) How to remove the cushion bearing in a double cushion mechanism
   Remove the piston nut. Then lightly tap piston rod (3) and cushion bearing (31) till snap ring (33) comes off, using a plastic mallet. Then slide cushion bearing (31) toward piston rod (3) and remove the stop ring (split) and then cushion bearing (31). Cushion seal (32) has a slit. Stretch the slit and take it off.

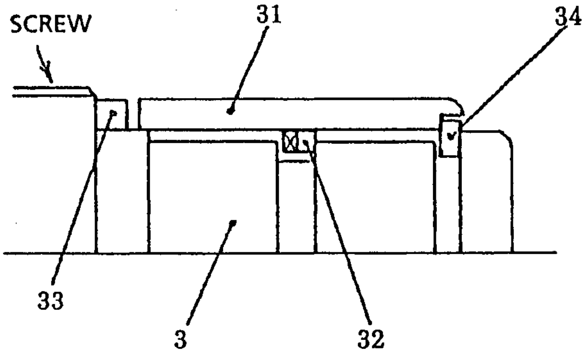


Fig. 16 Removing cushion ring (31)

5) For a cushioned mechanism, remove piston (9) and draw out shim (10) and cushion bearing (13).
6) For a cushion-less mechanism, remove piston (9) and draw out shim (10).

☞ Throw away piston (9) adfusting shim (10) at is not used again.

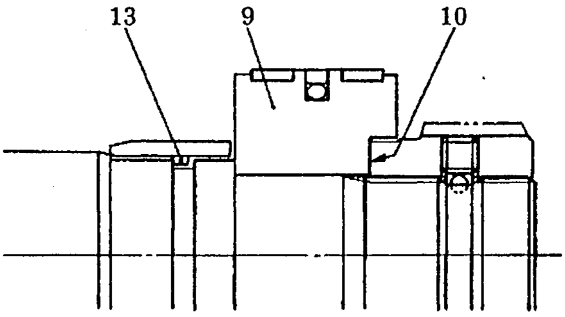


Fig. 17 Cushion spec. on the rod side

7) Remove the rod cover assembly from piston rod (3). If it is too heavy to move, move it by striking the flanged part of the rod cover (5) with a plastic hammer. Pull it straight with the rod cover assembly lifted with a crane or the like.

☞ When removing rod cover (5), exercise care so as not to score the lips of bush (6), the ring and the seal by the thread of piston rod (3).

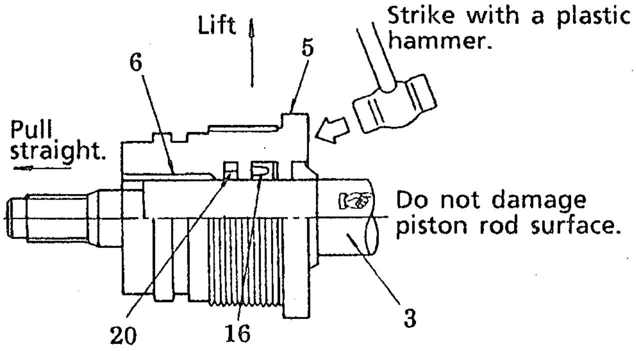

Lift
Strike with a plastic hammer.
6
5
Pull straight.
☞ Do not damage piston rod surface.
20
16
3

Fig. 18 Removing rod ccover assembly

3.2.3 DISASSEMBLING PISTON ASSEMBLY

1) Pierce the outer periphery of slide ring (26) through with a woodworking drill, hold it up and remove it. Cut off seal ring (24) by lightly tapping it with a screwdriver or a chisel as illustrated in fig. 19.

☞ Exercise care so as not to score the groove by strong blow or develop dents, chipping and burrs on the corner by prying the corner of the groove with a screwdriver. Otherwise the slide ring will become useless.

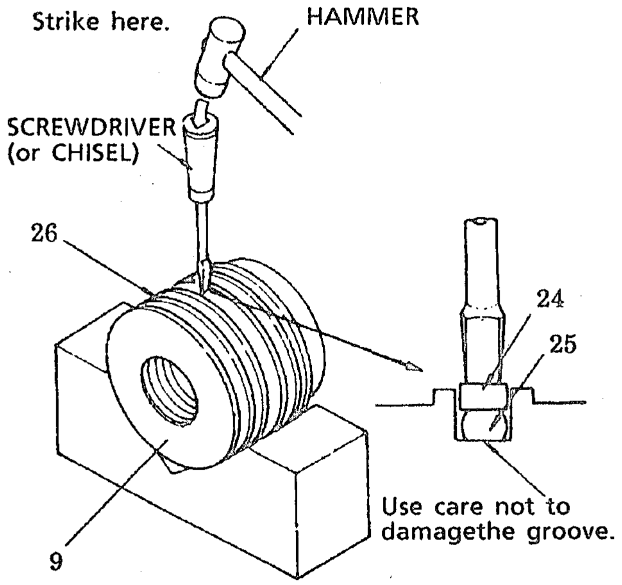

Strike here.
HAMMER
SCREWDRIVER
(or CHISEL)
26
24
25
Use care not to damagethe groove.
9

Fig. 19 Cut off seal ring (24)

3.2.4 DISASSEMBLING ROD COVER ASSEMBLY

1) Separate O rings (18, 21) and backup ring (19). Backup ring (19) comes off if the bias cut in one point of the circumference is extended. However, remove O rings (21, 18) by means of an earpick-like spatula or by the method illustrated in Fig. 20 or Fig. 21.

☞ ◎ Rod cover (5) with a cushion is equipped with O ring (22) and backup ring (23).

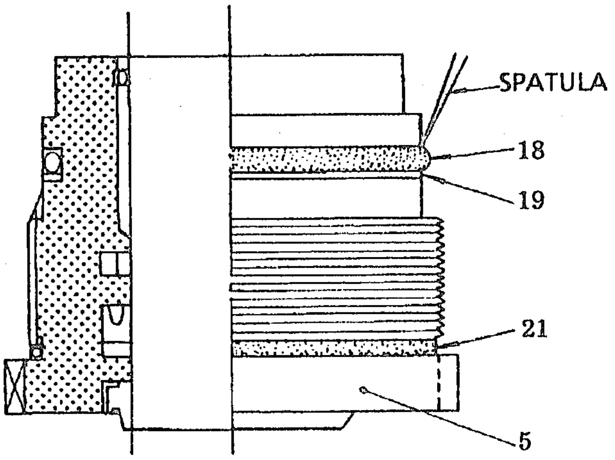

SPATULA
18
19
21
5

Fig. 20 How to remove the seal.

☞ ● How to remove O rings (18, 21) and backup ring (19)
press parts A and B of O rings (18, 21) by the tip of your two fingers. Then take out the swollen parts of the O rings by another hand. On that occasion, backup ring (19) can also be taken out.

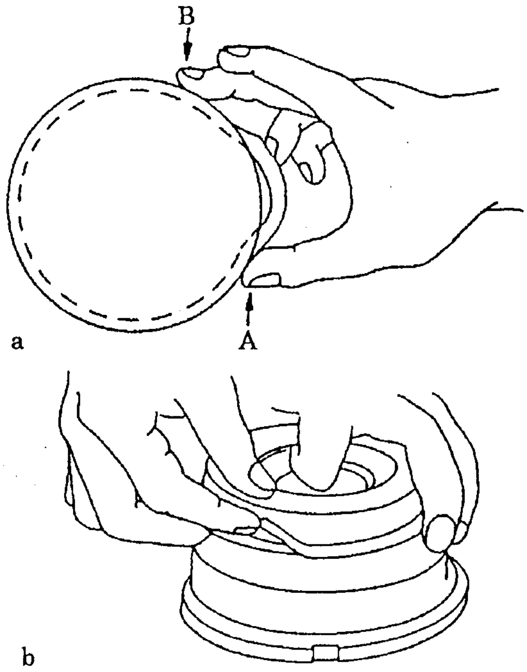


Fig. 21 How remove the seal

2) Remove buffer ring (20), backup ring (17) and U ring (16). Each seal is fixed in the groove on the bore and removing in flawless is impossible. Stab each seal with a gimlet and pull it out of the groove.

☞ Exercise care in this operation not to damage the grooves.

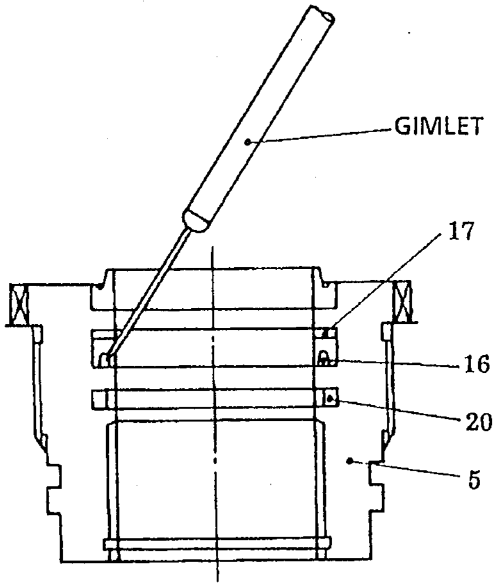
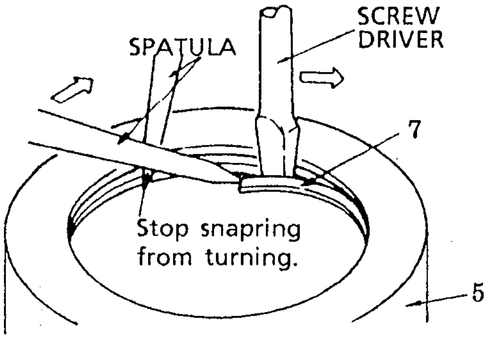


Fig. 22 How remove the seal

3) Remove snap ring (7) fastening rod cover (5) and bush (6) on the bore, using a screwdriver.



Stop snapring from turning.

Fig. 23 How remove snap ring (7)

4) Remove wiper Ring (15). When taking out wiper Ring (15), fix rod cover (5) in a vise.

☞ U ring (16) (see Fig. 22.), wiper ring (15), backup ring (17) and other O rings are scored when removed and can not be reused. Throw away separated parts.

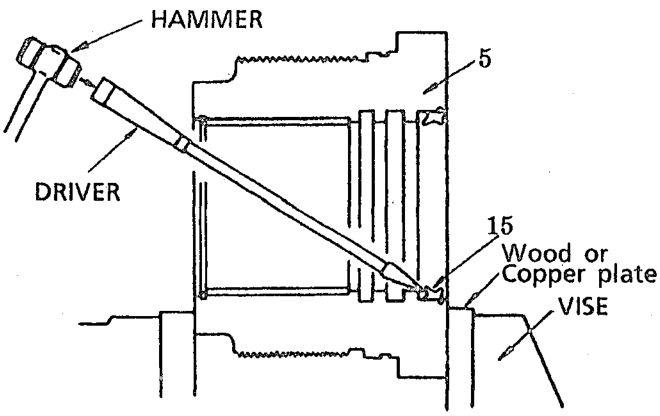

HAMMER
5
DRIVER
15
Wood or Copper plate
VISE

Fig. 24

5) Press out bush (6), using the bush removing jig.

☞ Bush (6) is hard fit to cylinder head (5). If you have failed to draw it out, lathe it to small thickness, insert a copper spatula hard into the clearance at the chamfered part of the opening and remove it as if it were peeled off. (For lathing, center the bush correctly and shear it off as thin as possible.

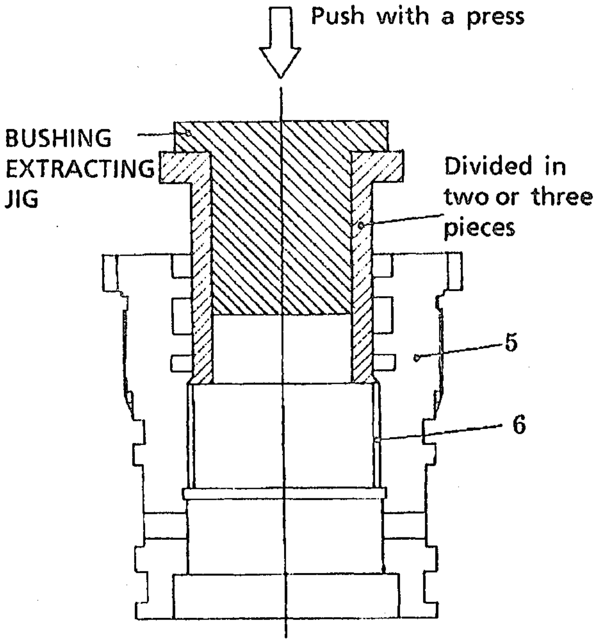

Push with a press
BUSHING EXTRACTING JIG
Divided in two or three pieces
5
6

Fig. 25

6) Draw out wiper rings (27, 28) with pin bushes (2, 4), using a batten metal and a press.

☞ For a single cushion mechanism, note that two pin bushes (2) are provided on the bottom side.

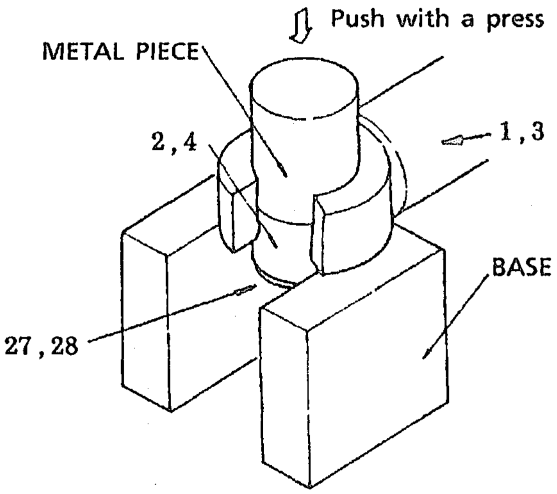

Push with a press
METAL PIECE
2,4
1,3
BASE
27,28

Fig. 26

3.2.5 CLEANING

1) When the cylinder has been disassembled, wash all parts with a suitable commercial detergent.

☞ Do not use volatile agents (gasoline and thinner) as they deteriorate rubber. However, do not reuse the wiper ring, the O rings and the backup rings if they have been proved serviceable on inspection.

2) After cleaning, dry all parts with jet air and place them on a clean work bench so that they may not be damaged.

3.3 ASSEMBLY

Start assembly with the subassemblies listed below.

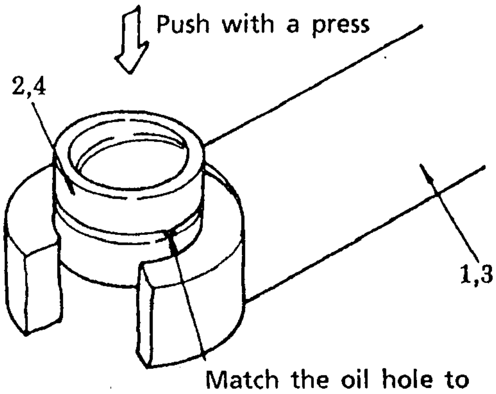
1. Cylinder tube ass'y
2. Piston rod ass'y
3. Piston ass'y
4. Rod cover ass'y

3.3.1 CYLINDER TUBE ASS'Y AND PISTON ROD ASS'Y

Press pin bushing (2, 4) into cylinder tube (1) and piston rod (3), using a press. Then insert wiper rings (27, 28) into both faces.

☞

For a single cushion mechanism, note that two pin bushes (2) are provided on the bottom side.



Push with a press

Match the oil hole to the grease hole.

Fig. 27 Pressing in pin bushing

3.3.2 PISTON ASSEMBLY

1) Fit O ring (25) and seal ring (24).
2) Coat O ring (25) with vaseline (hydraulic oil if not available) and fit it, using a fixing jig.

☞ A special jig as shown in Fig. 29 is needed to fit seal ring (24).

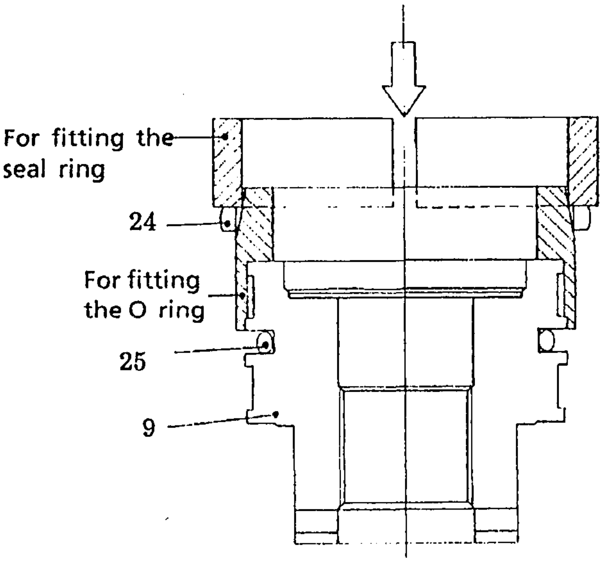


Fig. 28

3) Immediately after immersing seal ring (24) in 150~180°C (302~356°F) hydraulic oil for about five minutes, attach it to the groove on the outside of the piston, using a fitting jig. After fitting the seal ring, place it snugly in the piston groove, using a correction jig.

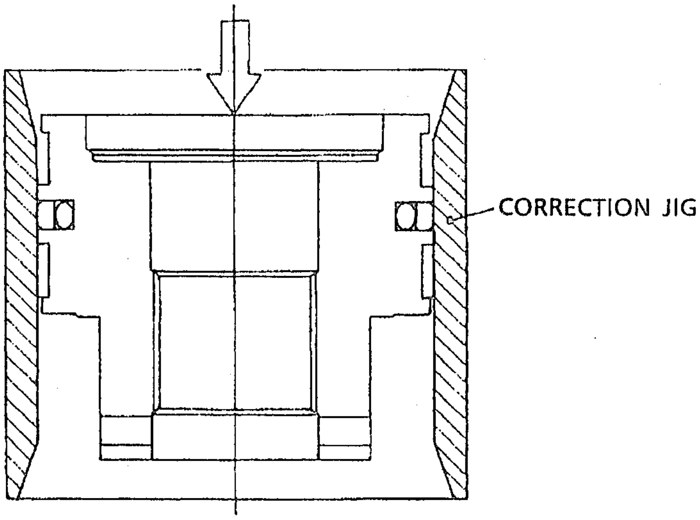

CORRECTION JIG

Fig. 29

☞ ◎ Use such hydraulic oil that has as high ignition point as possible for heating purpose and avoid such heating that brings fire direct contact with hydraulic oil in all circumstances.

◎ After dismantling the correction jig, place tape a few turns around the outer circumference of seal ring (24) and do not remove it till piston (9) is put into the cylinder tube.

◎ Attach slide ring (26) when piston (9) is inserted into cylinder tube (1).

3.3.3 ROD COVER ASSEMBLY

1) Press bushing (6) into cylinder head (5) using a metal ring. Thereafter fix snap ring (7) in to the groove.

☞ Before pressing in the bushing, coat the inner face of cylinder head (5) with hydraulic oil.

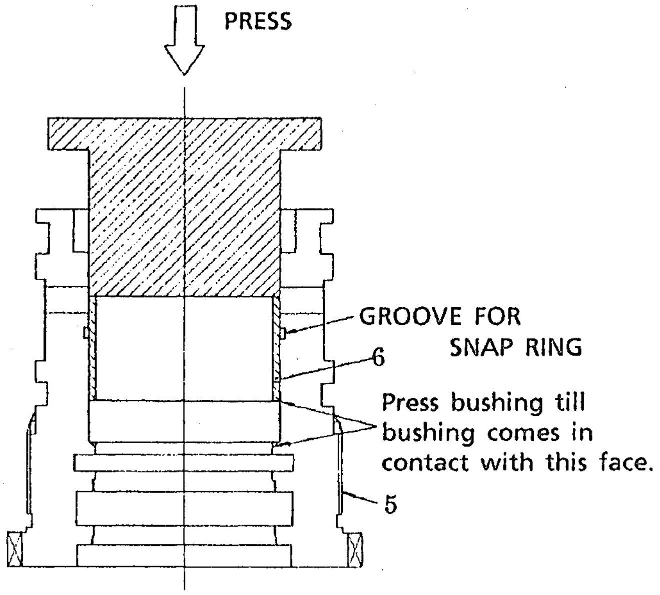

PRESS
GROOVE FOR SNAP RING
6
Press bushing till bushing comes in contact with this face.
5

Fig. 30

2) Fit square ring (20-1) of buffer ring (20) to the groove of the cylinder head, considering correct orientation. Then, deform slide ring (20-2) in a U-shape by the tip of your fingers, put it in the groove and fix it, pushing it out to the outer circumference. (Fig. 31)

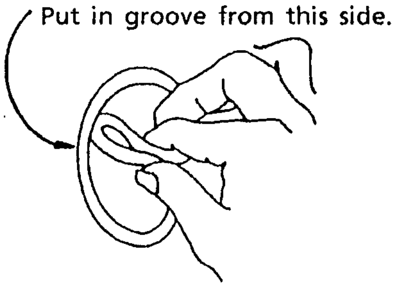

Put in groove from this side.

Fig. 31 How to fix slide ring (20-2)

☞ ● Note that if slide ring (20-2) is bent to too small radius, wrinkling will remain after fixing.

● Fit buffer ring (20) so the projection and the slit are set in a pressing direction.

● If you fix buffer ring (20) inversely, very high pressure is built up between the buffer ring and the U ring (16) and may distort cylinder head (5) in some cases.

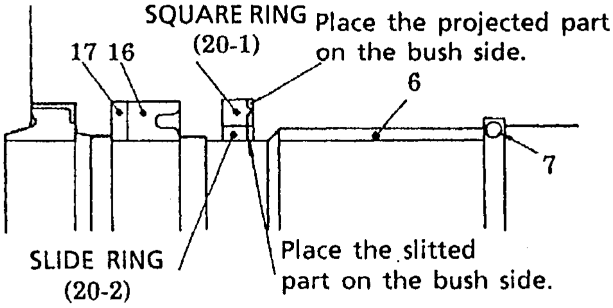

SQUARE RING
(20-1)
Place the projected part on the bush side.
17
16
6
7
SLIDE RING
(20-2)
Place the slitted part on the bush side.

Fig. 32 Detail of rod cover

3) Backup ring (17) fixed in the U ring (16) has one part cut off. Stretch the cutout, twisting it sideways and slide the backup ring into the groove.

4) U ring (16) is harder than other seal and it would be difficult to deform them in a heart shape. In such a case, put a rod packing in the groove obliquely by hand as deep as possible and push in the last part with a push bar till it is set with a click. (Fig. 33.)

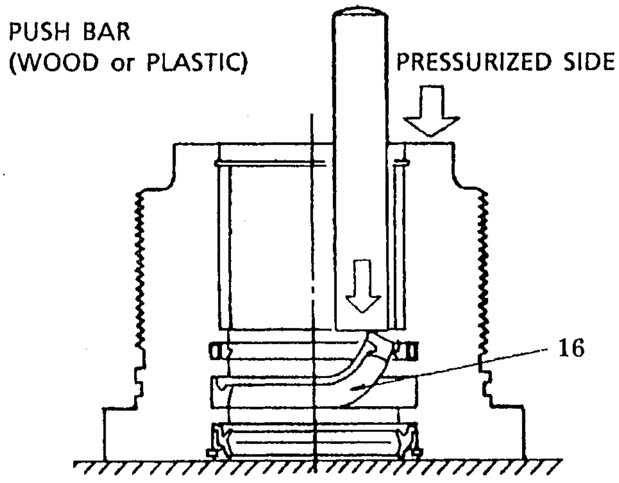

PUSH BAR
(WOOD or PLASTIC)
PRESSURIZED SIDE
16

Fig. 33 Method of fitting U ring (16)

☞ ● If U ring (16) is set upside down, the lip may be damaged. Check that it is positioned correctly.

● After fitting U ring (16) and backup ring (17), make sure that no wrinkle and permanent deformation are left.

5) Coat the outer circumference of wiper ring (15) with a thin film of vaseline or hydraulic oil and press wiper ring (15) into rod cover (5).

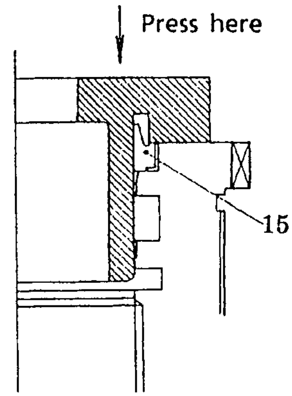

Press here
15

Fig. 34 Pressing in wiper ring (15)

6) Attach two O ring (18) and two backup rings (19) to the O.D. of rod cover (5) for a cushioned mechanism, and attach one O ring (18) and one backup ring (19) for a cushionless mechanism. Fit O ring (18) by pulling and stretching it by hand, but make sure that it is not twisted after fitting. Note that the position of backup ring (19) is related to that of O ring (18). (See Fig.35.)

☞ Always fit backup ring (19) to the outer air side of O ring (18).

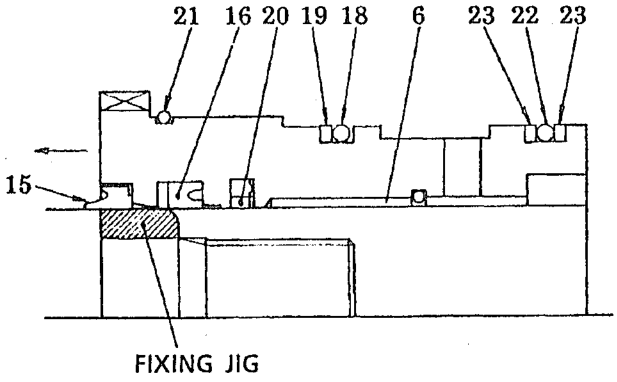
3.3.4 INSERTING THE ROD COVER ASS'Y INTO THE PISTON ROD

1) Fix piston rod (3) to the work bench.
2) Put lock washer (8) into cylinder head (5) and fit O ring (21).

☞ ◎ Before fitting O ring (21), coat it with vaseline (or hydraulic oil if not available) and use care so as not to score it by the thread of piston rod (3). (Taping on the thread is recommended for protection.)
◎ Fit O ring (21) to the groove by pulling it by hand, but make certain that it is not twisted after fitting.

3) Put the cylinder fixing jig into piston rod (3) and coat the out side of piston rod (3) and the bore of packings (15, 16, 20) and bush (6) with vaseline or hydraulic oil. Place the rod cover ass'y with care and slide it over piston rod (3) smoothly, exercising care so as not to score the lip of wiper ring (15).

☞ ◎ If it is difficult to slide the rod cover ass'y over the piston rod because of resistance of U ring (16) and buffer ring (20), tap the flanged part of rod cover (5) by means of a wooden or plastic mallet till it is set in place.
◎ When inserting or pressing in cylinder head (5), do not rotate it, but keep it straight.



図Fig. 35 Rod cover ass'y

4) Draw out rod cover (5) from rod cover ass'y (3).

3.3.5 INSERTING THE PISTON ASS'Y INTO THE PISTON ROD

1) For a cushion-less mechanism, apply vaseline or hydraulic oil to the shaft part that piston (9) of piston rod (3) enters, fit a shim (10), screw in the piston ass'y and tighten it temporarily.

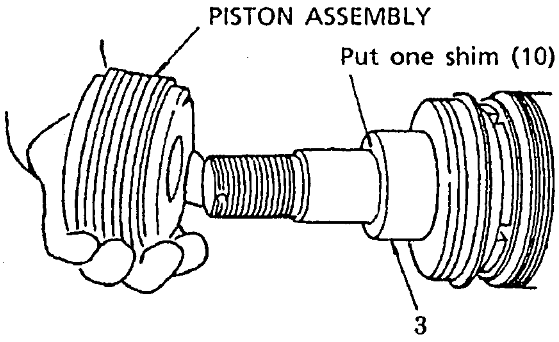


Fig. 36 Inserting the piston ass'y

2) For a cushioned mechanism, put cushion bearing (13) and shim (10) into piston rod (3), screw it in while pressing piston (9) and tighten it temporarily.

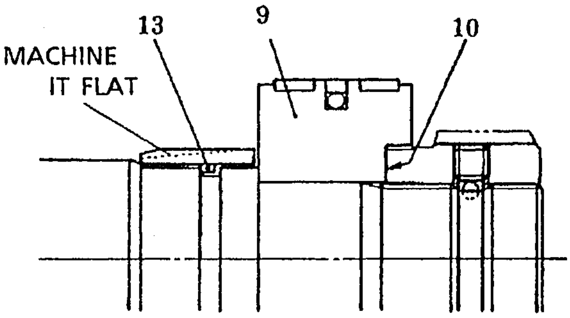


Fig. 37 Cushioned mechanism on the rod side

3) How to assemble cushion bearing (31) for double cushioned mechanism. (For arm)
Before fitting the piston nut, fix the cushion bearing. Put cushion seal (32) in the groove, assemble bearing (31) fully toward stopper (34) drive in snap ring (33). Lightly tap the rod and the cushion bearing so they may not be scored, using a plastic mallet.

☞ Keep in mind that cushion seal (32) and cushion bearing (31) have a direction in which they should be mounted.

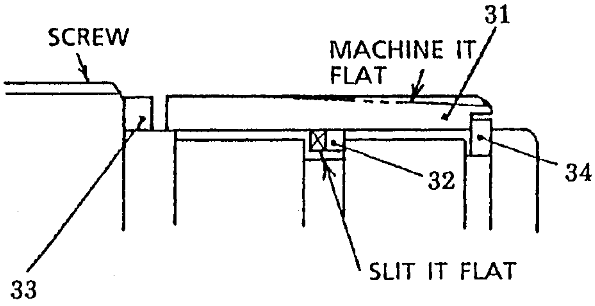


Fig. 38 Assembling the cushioned mechanism on the head side

4) Tighten piston (9) tentatively fastened to the piston rod ass'y to a specified torque, using an eye wrench with an extension pipe. If the tightening torque is high, tighten it, utilizing a hydraulic cylinder.

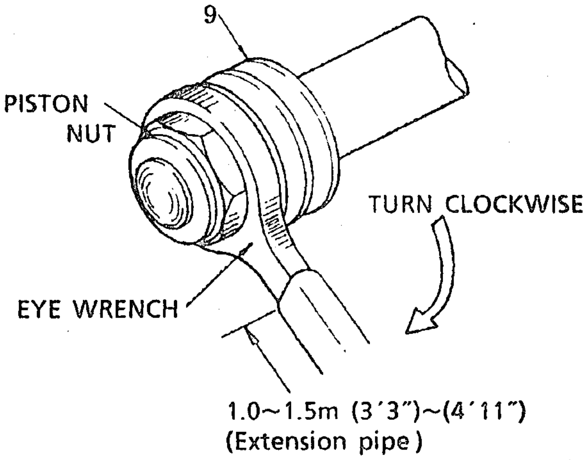

9
PISTON NUT
TURN CLOCKWISE
EYE WRENCH
1.0~1.5m (3'3")~(4'11")
(Extension pipe)

Fig. 39

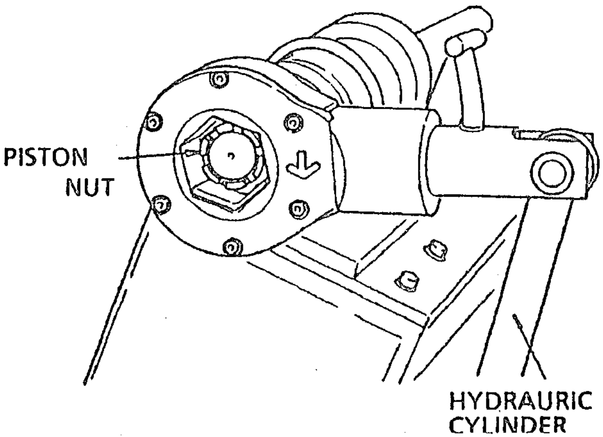

PISTON NUT
HYDRAURIC CYLINDER

Fig. 40

5) Insert ball (12) into the nut of piston (9) and fit set screw (11). If the pin can not be set when piston (9) is tightened to a specified torque, replace the shim with one of suitable thickness and tighten it again.

☞ Always use a single shim (10) instead of using multiple shims.

6) Stretch the bore of slide ring (26) by hand and fix it in the piston groove.

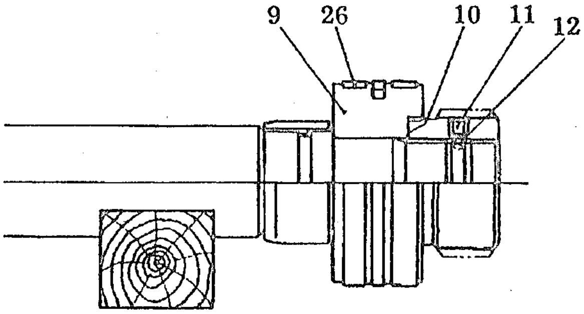


Fig. 41

3.3.6 OVERALL ASSEMBLY

1) Place a V-block on a rigid work bench (A wooden V-block is preferable.).
2) Mount the cylinder tube ass'y on it and fix the ass'y by passing a bar through the clevis pin hole to lock the ass'y.

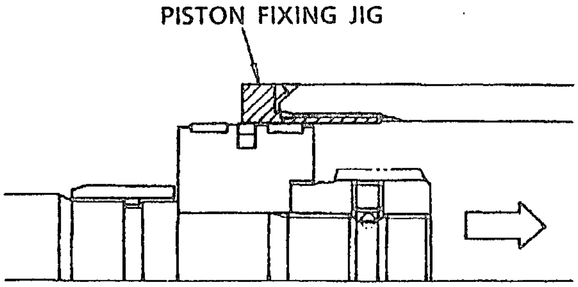

PISTON FIXING JIG

Fig. 42

3) Insert the piston rod ass'y into the cylinder tube ass'y, while lifting the piston rod ass'y by crane and moving it.

4) Apply vaseline (or hydraulic oil if not available) to the bore of tube opening and the outer surface of the piston. Center the piston rod ass'y to the cylinder tube ass'y and insert it straight.

☞ When inserting the piston rod ass'y, make sure that slide ring (26) on the outer circumference of the piston is not above the groove.

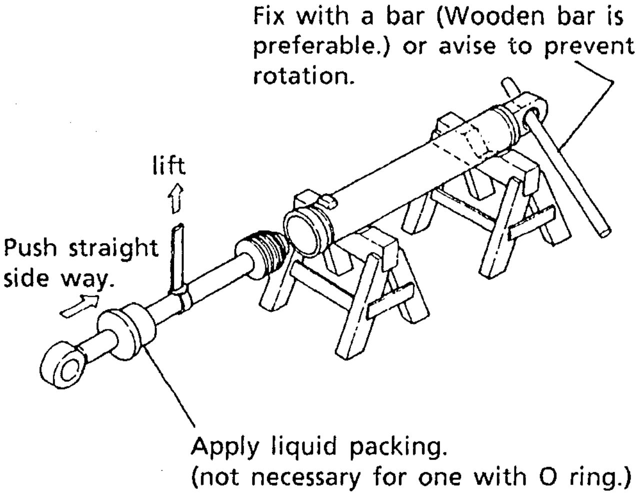

Fix with a bar (Wooden bar is preferable.) or avise to prevent rotation.
lift
Push straight side way.
Apply liquid packing.
(not necessary for one with O ring.)

Fig. 43 Method of pushing in the piston rod ass'y

5) Apply proper amount of liquid packing over full surface in the flange-side corner on the outer circumference of rod cover (5).

☞ This treatment aims at preventing rusting on the outer circumference of rod cover (5) by intrusion of moisture. However, the treatment is not necessary if an O ring is attached to this position.

6) Screw rod cover (5) into cylinder tube (1) by a few thread peaks, while turning the rod cover by hand, and insert the piston rod ass'y.

☞ ● Apply vaseline (or hydraulic oil if not available) over the outer surface of O rings (18, 22) and backup rings (19, 23).

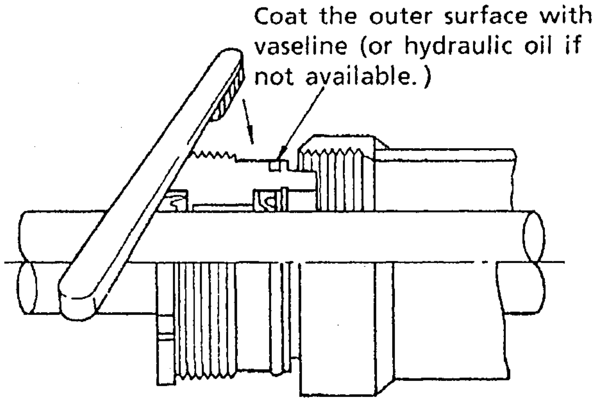

Coat the outer surface with vaseline (or hydraulic oil if not available.)

Fig. 44 Screwing in rod cover (5)

7) After inserting the piston, screw in rod cover (5) to full depth and tighten it to a specified torque.

☞ ● Use care so as not to score the surface of the rod by slipping a hook wrench or something when rod cover (5) is tightened. (We recommend to cover the rod surface with rag or something.)

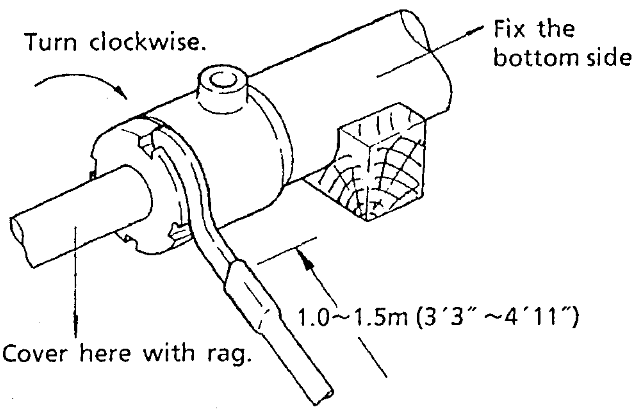
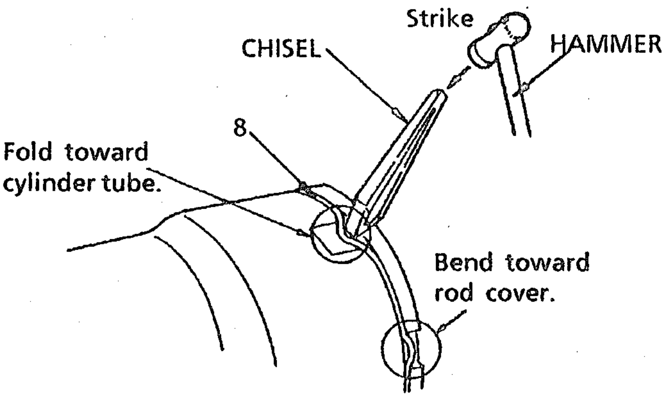

Turn clockwise.
Fix the bottom side
1.0~1.5m (3'3" ~4'11")
Cover here with rag.

Fig. 45 Tightening rod cover

8) When rod cover (5) has been completed, fold one part of lock washer (8) into the groove of cylinder tube (1) and rod cover (5) to lock it.
9) This completes assembly operation. Apply grease to the surface of bush (2, 4) for the rod pin and plug each port.


Strike
CHISEL
HAMMER
8
Fold toward cylinder tube.
Bend toward rod cover.

Fig, 46

3.4 INSPECTION AFTER ASSEMBLY

(1) No-load functional test

Place the cylinder level under no load. Pressurize it from the retracting-side port, actuate the piston rod several strokes and check that the cylinder functions without irregularity.

☞ ◎ Do not raise the pressure beyond the maximum working pressure of the cylinder mounted in the excavator.
◎ Grease coated on the O rings and the seals of the cylinder head may ooze out. Wipe it off and retest the cylinder in such a case.

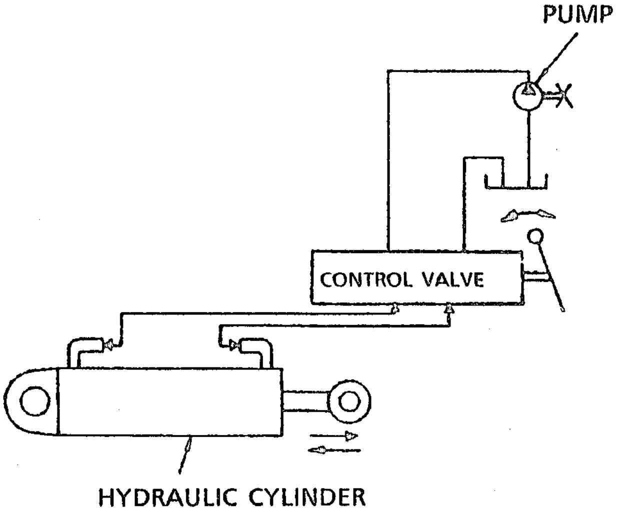
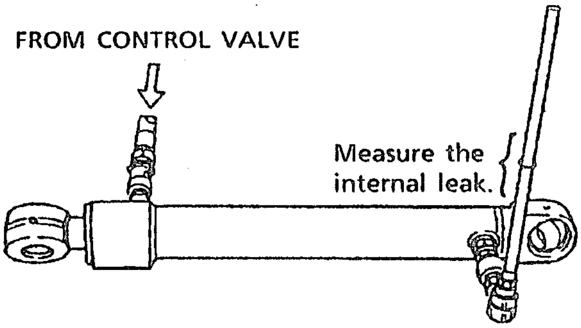

PUMP
CONTROL VALVE
HYDRAULIC CYLINDER

Fig. 47 External leak test

(2) Leak test

1) Apply a test pressure to the retracting and extending sides of the cylinder for three minutes independently, and check that the rod section and the welds have external leaks and permanent deformation. For an internal leak test, connect the cylinder with a test unit shown in Fig.48.


FROM CONTROL VALVE
Measure the internal leak.

Fig, 48 Internal leak test

2) After completing the test, apply a plug to each port and store it (Fig.49).

☞ For storage, place the cylinder on wooden V-blocks and bring the cylinder to the most retracted condition.

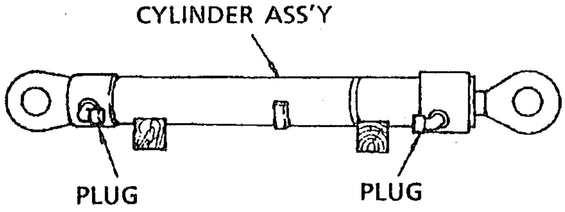

CYLINDER ASS'Y
PLUG
PLUG

Fig. 49 How to store the cylinder

4. MAINTENANCE STANDARDS

4.1 INSPECTION AFTER DISASSEMBLY

Visually inspect all parts after cleaning to see that excessive wear, crack and other faults that are detrimental to use are not present.

(1) Inspection Item

Table 4

Part Name	Inspecting Section	Inspection Item	Remedy
Piston rod	1. Neck of rod pin	Presence of crack	Replace.
	2. Weld on rod hub	Presence of crack	Replace.
	3. Stepped part to which piston is attached.	Presence of crack	Replace.
	4. Threads	Presence of seizure	Recondition or replace.
	5. Bend	Measure degree of bend (See Fig.50.)	Refer to Table 5.
	6. Plated surface	1) Plating is not worn off to base metal.	1) Replace or replate.
		2) Rust is not present on plating.	2) Replace or replate.
		3) Scratches are not present.	3) Recondition, replate or replace.
	7. Rod	Wear of O.D.	Recondition, replate or replace.
	8. Bushing at mounting part	Wear of I.D.	Replace.
Cylinder tube	1. Weld on bottom	Presence of crack	Replace.
	2. Weld on head	Presence of crack	Replace.
	3. Weld on hub	Presence of crack	Replace.
	4. Tube interior	Presence of faults	Replace if oil leak is seen.
	5. Bushing at mounting part	Wear on inner surface	Replace.
Rod cover	1. Bushing	1) Wear on inner surface	1) See para. 4.2.
		2) Flaw on inner surface	2) Replace if flaw is deeper than coating.

(2) Repair method

Check all seals and parts to see that they do not show excessive damage and wear. For correction of faults on the piston rod, observe the following procedure:

1) Correct very fine longitudinal scratches with an oilstone. Replace the piston rod if the scratch is so deep as may be caught by your nail.
2) In case of a smooth indention, recondition by removing the sharp area around the indention with an oilstone. If the flaw or the indention is excessive, replace or replate the faulty part.

☞
- Always regrind after replating. The thickness of the plating must be maximum 0.1mm (0.004").
- In case plating is removed to the base metal during reconditioning with an oilstone, do not fail to replate the surface.

4.2 LIMIT OF SERVICEABILITY

Serviceability limits represent the limits of wear on the sliding surfaces of the cylinder tube and the rod that have no such faults as may degrade the sealing effect.

(1) Clearance between piston rod and rod bushing
Replace the bushing if the clearance between the piston rod and the rod bushing exceeds 0.25 mm (0.01").

(2) Bend of piston rod
The allowable bend of the rod is maximum 1 mm / 1m (0.004" / 3'3"). For measurement, support both ends of the parallel section of the piston rod with V-blocks, set a dial indicator in the center between the two V-blocks, turn the piston rod, and read the difference between the maximum minimum oscillations on the dial indicator.

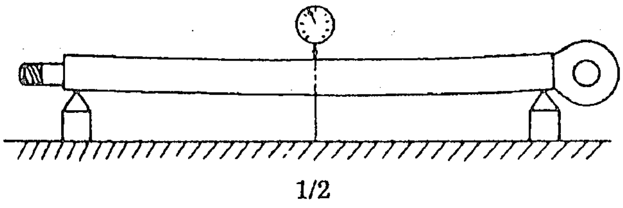


Fig. 50 Measuring method

Table 5 shows an example of measurement.

Table 5 Example of Measurement

Spacing between V-blocks (m) (ft·in)	Intermediate Value in Dial Indicator Readings (mm) (in)	Remedy
	1/2 (0.02")	
1 (3'3")	1 (0.04")	Replace

☞ Even if the bend is within the above limit, the cylinder may not operate smoothly because of localized bend. Beware of it during functional test after assembly. Replace the rod if the cylinder makes a squeaking noise or does not operate smoothly.

4.3 TIGHTENING TORQUE

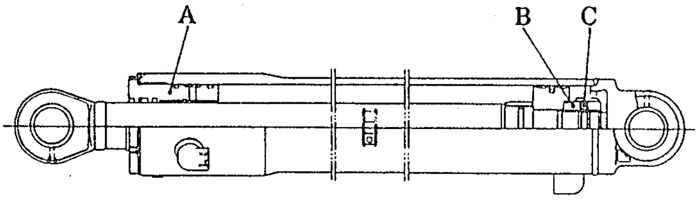


Fig. 51

Table 6 Unit: kgf·m (ft·lbs)

Cylinder	A Rod cover	B Piston nut	C Capscrew
Arm	85 (614)	277 (2000)	3.21±0.6 (23±4)
Bucket	58 (419)	152 (1100)	3.21±0.6 (23±4)
Boom	123 (888)	259 (1870)	5.8±1.09 (42±8)

☞ Before tightening the rod cover, coat the threads with Three Bond #1901.

4.4 VOLUME OF OIL LEAKAGE

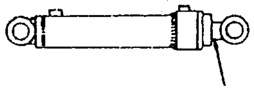
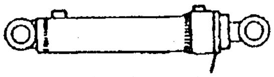
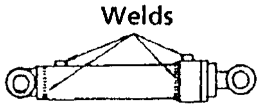
The oil leak rates as mentioned in (2) of "Inspection after Assembly" are as shown in Table 7.

Table 7

Cylinder	Volume of Internal Oil Leakage
Arm	1cc (0.06cuin) / 3 min or below
Bucket	
Boom	

5. TROUBLESHOOTING

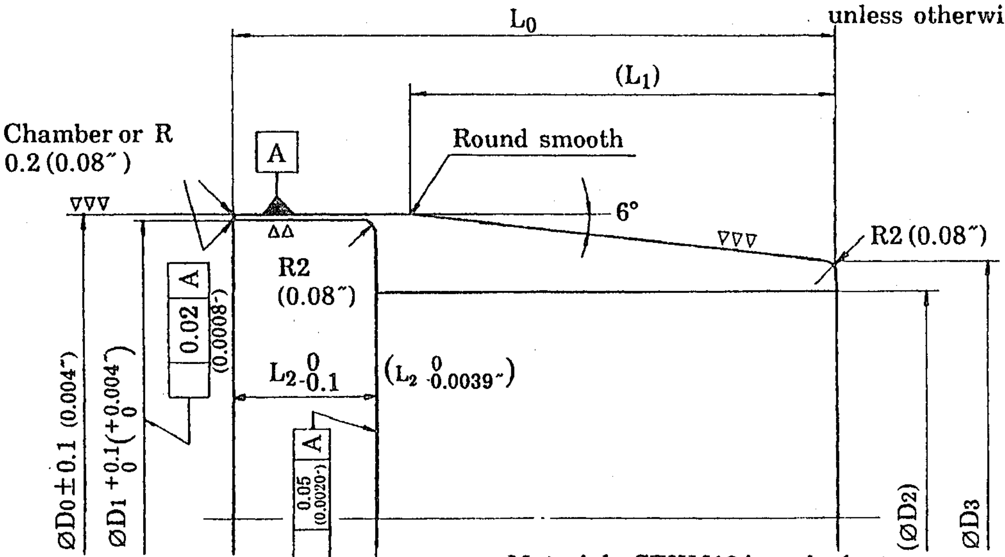
Table 8

Trouble	Faulty Part	Cause	Remedy
1. Oil leaks through the sliding surface of piston rod. (Oil ring is formed on piston rod and drops spreading.)  Oil leaks from here.	1. U ring	1. Foreign matter is caught in the bore of U ring.	1. Remove foreign matter.
		2. Flaw is present on the inner face, outer face and lip of U ring.	2. Replace U ring.
		3. Other irregularity of U ring.	3. Replace U ring.
	2. Buffer ring	1. Foreign matter is caught in the bore of buffer ring.	1. Eliminate foreign matter.
		2. Flaw is present on the bore of buffer ring.	2. Replace buffer ring.
		3. Other irregularity of buffer ring.	3. Replace buffer ring.
	3. Wiper ring	1. Foreign matter is caught on the bore of wiper ring.	1. Remove foreign matter.
		2. Flaw is present on the bore of wiper ring.	2. Replace wiper ring.
		3. Other irregularity on wiper ring.	3. Replace wiper ring.
	4. Piston rod	1. Flaw is present on the sliding surface of piston rod.	1. Smooth out the sliding surface with an oilstone. (Less than 1.6S) If the leakage persists in spite of the above measure, U ring may be damaged. Disassemble and inspect the rod, and replace U ring. If the leakage still continues, replace piston rod.
		2. Hard chromium plating has peeled off.	2. Replate.
2. Oil leaks from the perimeter of cylinder head.  Oil leaks from here.	1. O ring	1. O ring is damaged.	1. Replace O ring.
	2. Back-up ring	1. Back-up ring is damaged.	1. Replace Back-up ring.
3. Oil leaks from welds.  	1. Cylinder tube	1. Welds of cylinder are fractured.	1. Replace cylinder tube.
4. Cylinder falls by itself (When the rod is subject to a static load equal to the maximum working pressure multiplied by the area of the cylinder, the maximum travel of the piston is more than 0.5 mm in ten minutes.)	1. Slide ring	1. Foreign matter is caught on the sliding surface of slide ring.	1. Remove foreign matter.
		2. Flaw is present on the sliding surface of slide ring.	2. Replace slide ring.
		3. Other irregularity of slide ring.	3. Replace slide ring.
	2. Seal ring	1. Flaw is present on the sliding surface of seal ring.	1. Replace seal ring.
	3. O ring	1. O ring is damaged.	1. Replace O ring.

6. TOOLS AND JIGS LIST

(1) Seal ring fixing jig (I)

Machine surface to▽finish unless otherwise specified.


L0
(L1)
Chamber or R
0.2 (0.08″)
▽▽▽
A
Round smooth
6°
▽▽▽
R2 (0.08″)
ΔΔ
R2
(0.08″)
0.02 A
(0.0008″)
L2-0.1 0
(L2 -0.0039″ 0)
0.05 A
(0.0020″)
ØD0±0.1 (0.004″)
ØD1 +0.1 0 (+0.004″ 0)
(ØD2)
ØD3

Material: STKM13A equivalent

Fig. 52

Table 9 Unit: mm (in)

Applicable cylinder	D_0	D_1	(D_2)	D_3	L_0	(L_1)	L_2
Bucket	96 (3.780″)	95 (3.740″)	71 (2.80″)	81 (3.19″)	100 (3.94″)	72 (2.83″)	23 (0.906″)
Arm	111 (4.370″)	110 (4.330″)	86 (3.39″)	96 (3.78″)	100 (3.94″)	72 (2.83″)	24 (0.945″)
Boom	126 (4.961″)	125 (4.921″)	101 (3.98″)	111 (4.37″)	100 (3.94″)	72 (2.83″)	24 (0.945″)

(2) Seal ring fixing jig (II)

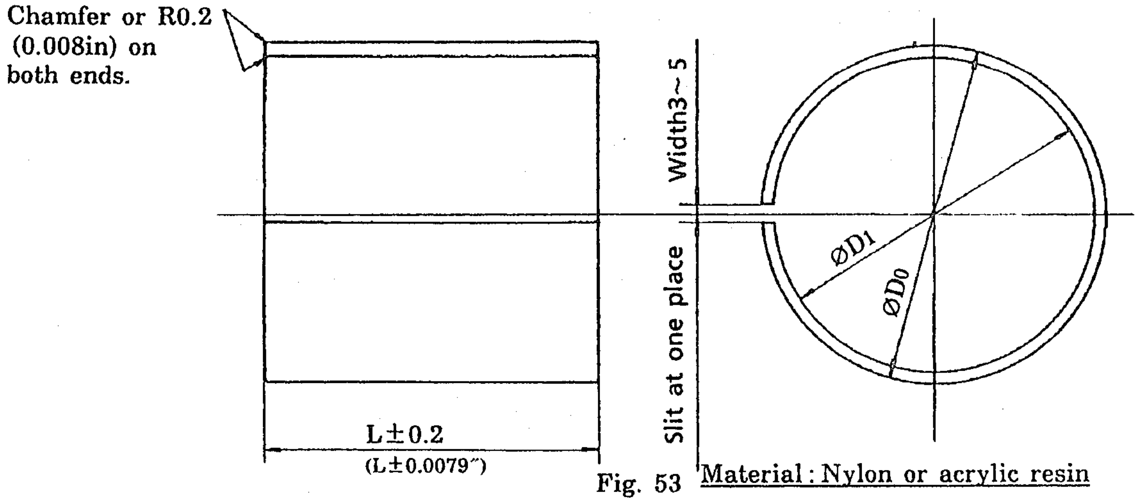

Chamfer or R0.2
(0.008in) on
both ends.
L±0.2
(L±0.0079″)
Width3~5
Slit at one place
ØD1
ØD0

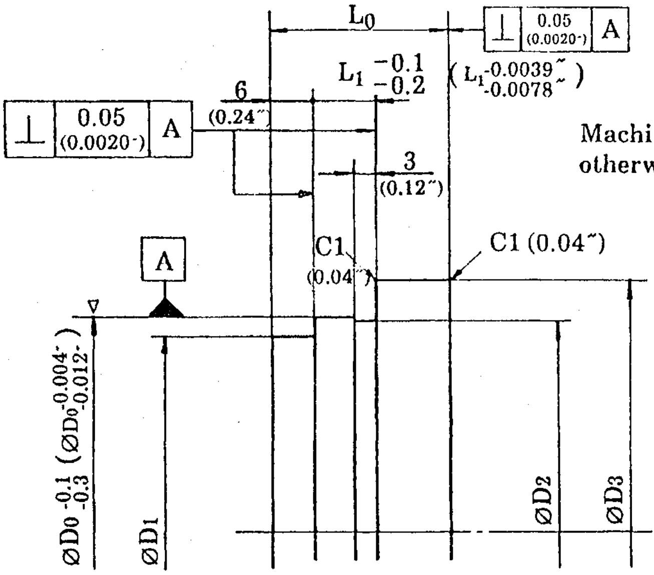
Fig. 53

Material: Nylon or acrylic resin

Table 10 Unit: mm (in)

Applicable cylinder	D_0	D_1	L
Bucket	97 (3.82″)	89 (3.50″)	100 (3.94″)
Arm	112 (4.41″)	104 (4.09″)	100 (3.94″)
Boom	127 (5.00″)	119 (4.69″)	100 (3.94″)

(3) Bush fixing jig


L0
⊥ 0.05 (0.0020") A
L1 -0.1 -0.2 (L1 -0.0039" -0.0078")
6 (0.24")
⊥ 0.05 (0.0020") A
3 (0.12")
A
C1 (0.04")
C1 (0.04")
ØD0 -0.1 -0.3 (ØD0 -0.004" -0.012")
ØD1
ØD2
ØD3

Machine surface to▽finish unless otherwise specified.

Fig. 54

Material : STKM13A equivalent

Table 11

Unit : mm (in)

Applicable cylinder	D0	D1	D2	D3	L0	L1
Bucket	65 (2.559")	59.5 (2.34")	58 (2.28")	85 (3.35")	25 (0.98")	13.3 (0.52")
Arm	70 (2.760")	64.5 (2.54")	63 (2.48")	90 (3.54")	65 (2.56")	53 (2.09")
Boom	75 (2.953")	59.5 (2.34")	68 (2.68")	95 (3.74")	65 (2.56")	53 (2.09")

Machine to▽finish unless otherwise specified.

(4) Wiper ring (cylinder head) fixing jig

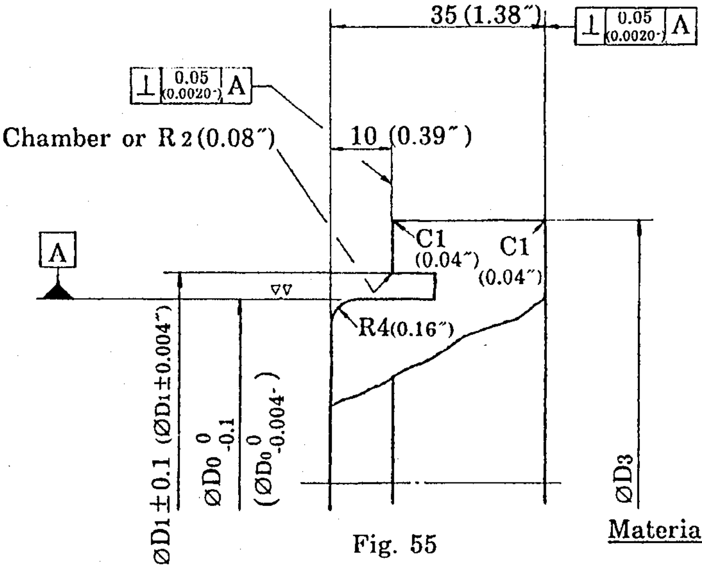

35 (1.38")
⊥ 0.05 (0.0020") A
⊥ 0.05 (0.0020") A
Chamber or R2 (0.08")
10 (0.39")
A
C1 (0.04")
C1 (0.04")
▽▽
R4 (0.16")
ØD1 ±0.1 (ØD1 ±0.004")
ØD0 0 -0.1 (ØD0 0 -0.004")
ØD3

Fig. 55

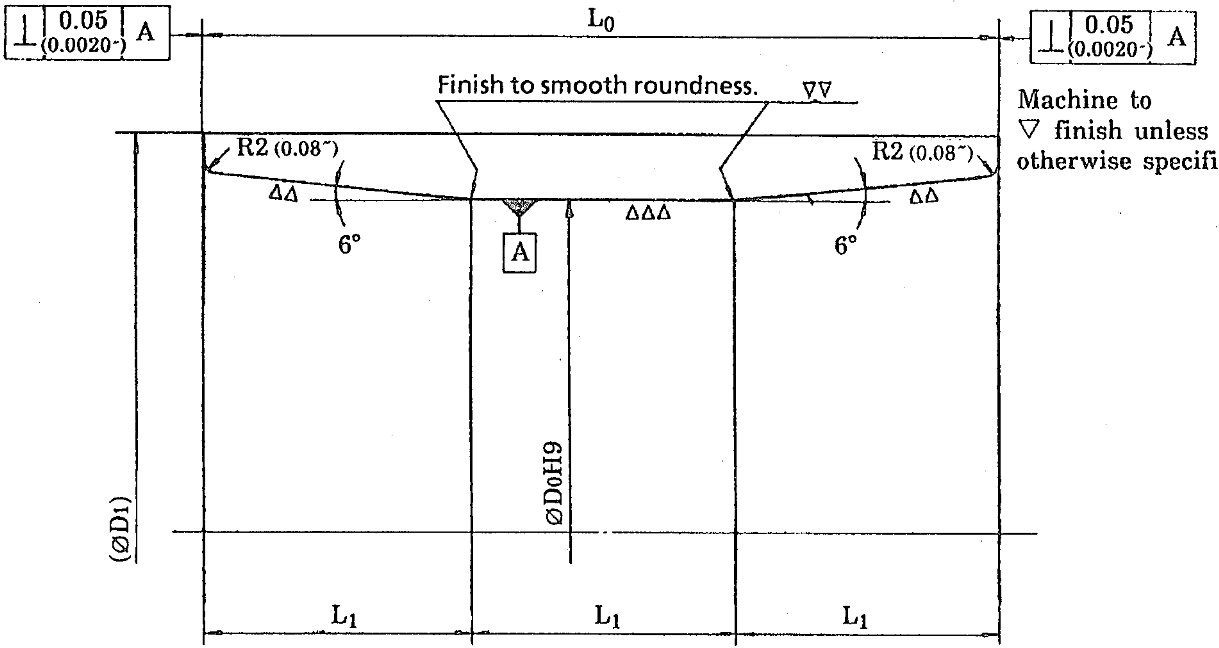
Material : STKM13A equivalent

Table 12

Unit : mm (in)

Applicable cylinder	D0	D1	L
Bucket	60 (2.362")	68.5 (2.697")	85 (3.35")
Arm	65 (2.559")	73.5 (2.894")	90 (3.54")
Boom	70 (2.756")	78.5 (3.091")	95 (3.74")

(5) Seal ring correcting jig


⊥ 0.05 (0.0020") A
L0
⊥ 0.05 (0.0020") A
Finish to smooth roundness. ▽▽
R2 (0.08")
R2 (0.08")
ΔΔ
ΔΔΔ
ΔΔ
6°
6°
A
ØD0H9
(ØD1)
L1
L1
L1

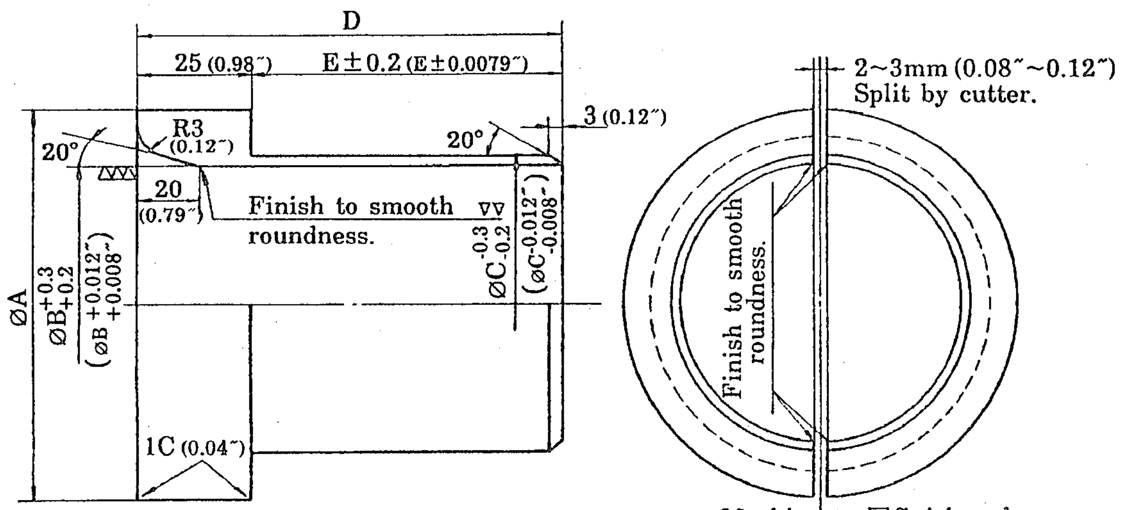
Machine to ▽ finish unless otherwise specified.

Fig. 56 Material : STKM13A equivalent

Table 13 Unit :mm (in)

Applicable cylinder	D0	(D1)	L0	L1
Bucket	$95^{+0.087}_{0}$ $(3.7402'' {}^{+0.0034''}_{0})$	115 (4.53")	120 (4.72")	40 (1.57")
Arm	$110^{+0.087}_{0}$ $(4.3307'' {}^{+0.0034''}_{0})$	130 (5.12")	120 (4.72")	40 (1.57")
Boom	$125^{+0.100}_{0}$ $(4.9213'' {}^{+0.0039''}_{0})$	145 (5.71")	120 (4.72")	40 (1.57")

(6) Piston fixing jig


D
25 (0.98")
E±0.2 (E±0.0079")
3 (0.12")
20°
R3 (0.12")
20°
▽▽▽
20 (0.79")
Finish to smooth roundness. ▽▽
ØC-0.3 -0.2
(ØC-0.012" -0.008")
ØA
ØB+0.3 +0.2
(ØB +0.012" +0.008")
1C (0.04")
2~3mm (0.08"~0.12") Split by cutter.
Finish to smooth roundness.

Machine to : STKM13A equivalent

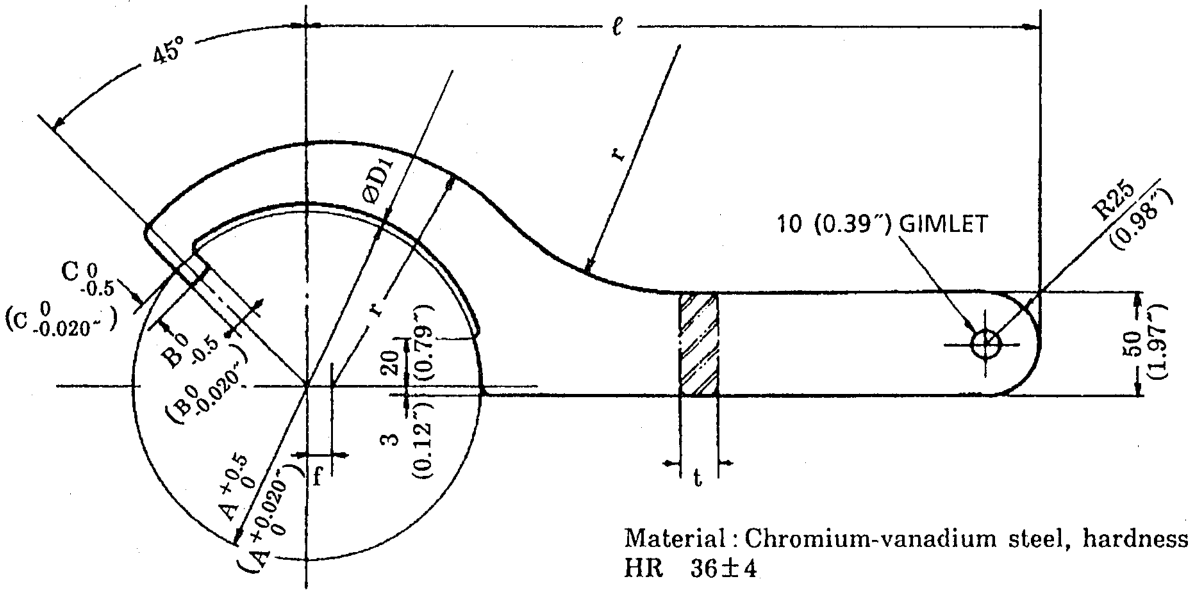
Fig. 57

Machine to ▽finish unless otherwise specified.

Table 14 Unit :mm (in)

Applicable cylinder	ØA	ØB	ØC	D	E
Bucket	112 (4.41")	95 (3.740")	98 (3.858")	67 (2.64")	42 (1.65")
Arm	125 (4.92")	110 (4.331")	113 (4.449")	67 (2.64")	42 (1.65")
Boom	141 (5.55")	125 (4.921")	128 (5.039")	72 (2.83")	47 (1.85")

(7) Hook wrench (symbol FS')


45°
ℓ
r
ØD1
r
10 (0.39") GIMLET
R25 (0.98")
C 0 -0.5
(C 0 -0.020")
B 0 -0.5
(B 0 -0.020")
A +0.5 0
(A +0.020" 0)
f
20 (0.79")
3 (0.12")
50 (1.97")
t

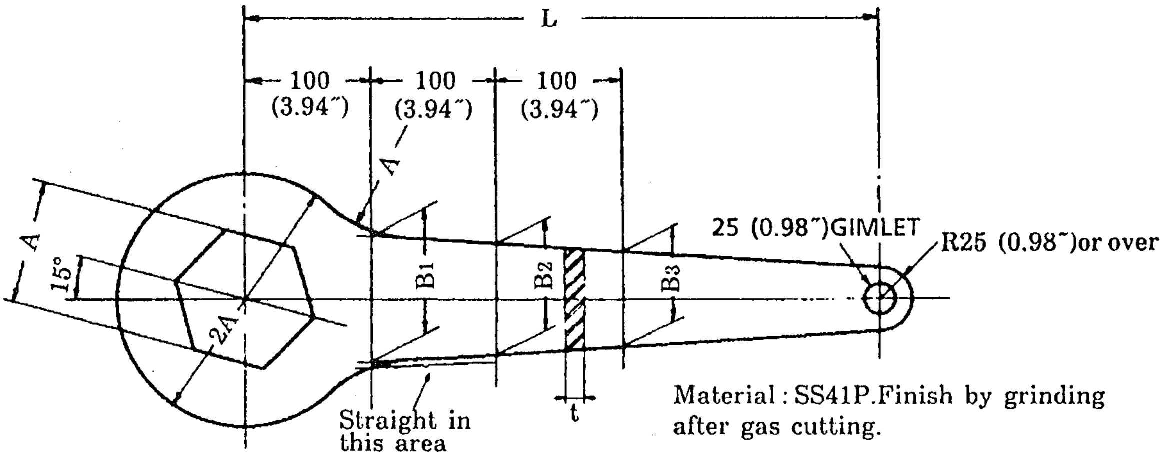
Material : Chromium-vanadium steel, hardness HR 36±4

Fig. 58

Table 15 Unit :mm (in)

Applicable cylinder	A	B	C	t	D	r	f	ℓ
Bucket	128 (5.04")	12 (0.47")	5 (0.20")	15 (0.59")	2 (0.08")	86 (3.4")	12 (0.47")	380 (15")
Arm	138 (5.43")	12 (0.47")	5 (0.20")	15 (0.59")	2 (0.08")	93 (3.7")	12 (0.47")	460 (18")
Boom	153 (6.02")	12 (0.47")	5 (0.20")	20 (0.79")	2 (0.08")	98 (3.9")	12 (0.47")	500 (20")

(8) Eye wrench (Symbol SS)


L
100 (3.94")
100 (3.94")
100 (3.94")
A
A
15°
2A
B1
B2
B3
25 (0.98")GIMLET
R25 (0.98")or over
t
Straight in this area

Material : SS41P.Finish by grinding after gas cutting.

Fig.59

Tolerance of A : 0.3mm (0.012") ~ 0.8mm (0.031")

Table 16 Unit :mm (in)

Applicable cylinder	Open end size	L=300 (12")			L=500 (20")			
	A	B1	B2	t	B1	B2	B3	t
Bucket	65 (2.56")	95 (3.74")	67 (2.64")	25 (0.98")	104 (4.09")	96 (3.78")	78 (3.07")	25 (0.98")
Arm	70 (2.76")	100 (3.94")	70 (2.76")	28 (1.10")	108 (4.25")	90 (3.54")	77 (3.03")	28 (1.10")
Boom	80 (3.15")	110 (4.33")	78 (3.07")	28 (1.10")	122 (4.80")	107 (4.21")	87 (3.43")	28 (1.10")

Book code No. S5 21022 2 E

KOBELCO

SHOP MANUAL

REDUCTION UNIT (SWING)

21

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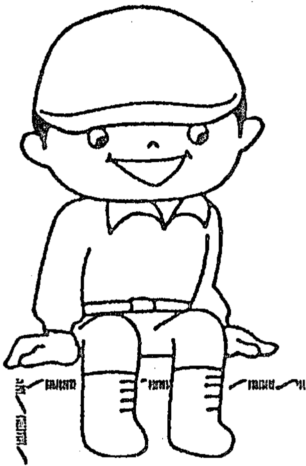
KOBE STEEL, LTD.



PREFACE

This manual provides instruction of a single reduction unit (swing). Refer to the separate manual concerning duties and functions of reduction unit (swing) used on the hydraulic excavator.

Models	Applicable Machines	Notes	Models	Applicable Machines	Notes
SK60	LE-11001~				

Revision	Date of Issue	Remarks
First edition	June,1990	S5210222E K

1. SPECIFICATION

1.1 GENERAL VIEW

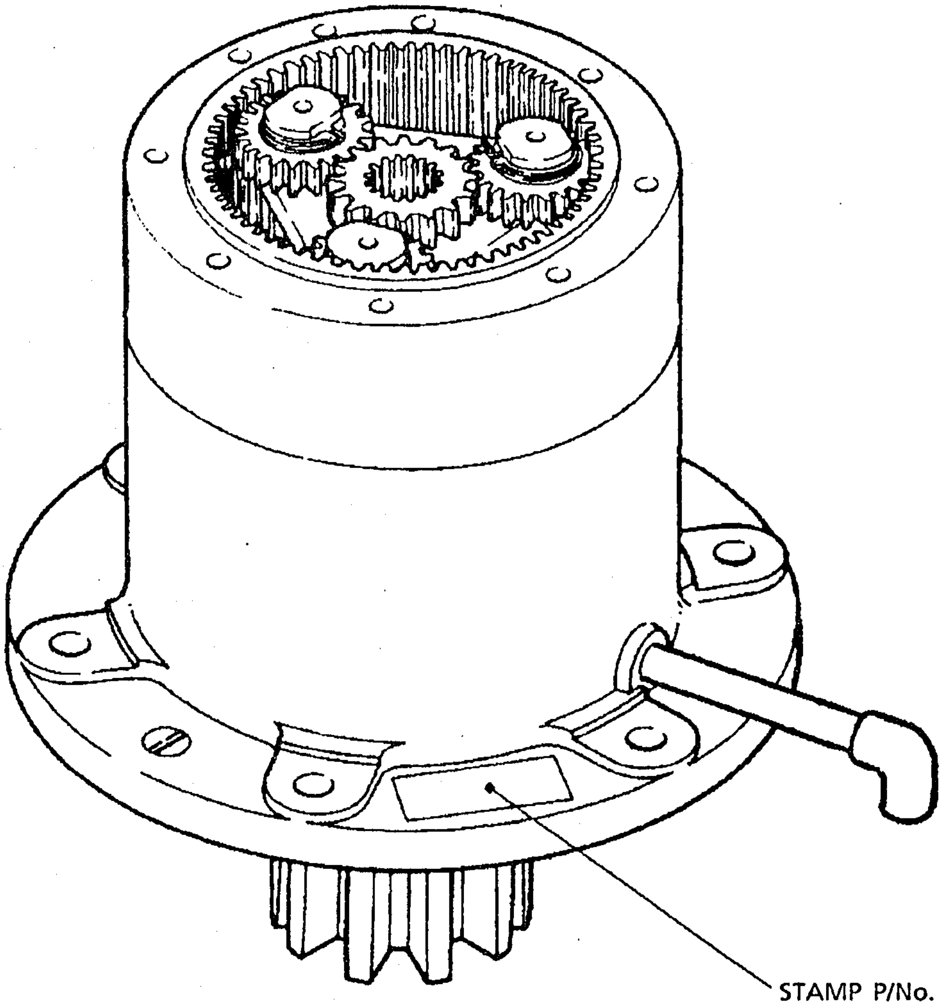


Fig. 1 Outside view of reduction unit

1.2 MAJOR SPECIFICATIONS

Table 1

Type	–
Reduction ratio	15.429
O. D.	306mm (12 in)
Height	365mm (14.04 in)
Weight	56kg (123 lbs)
Quality of oil	Engine oil API Group CD Class SAE30
Oil quantity	4.0ℓ (1.06 gal)

2. CONSTRUCTION AND FUNCTION

2.1 CONSTRUCTION

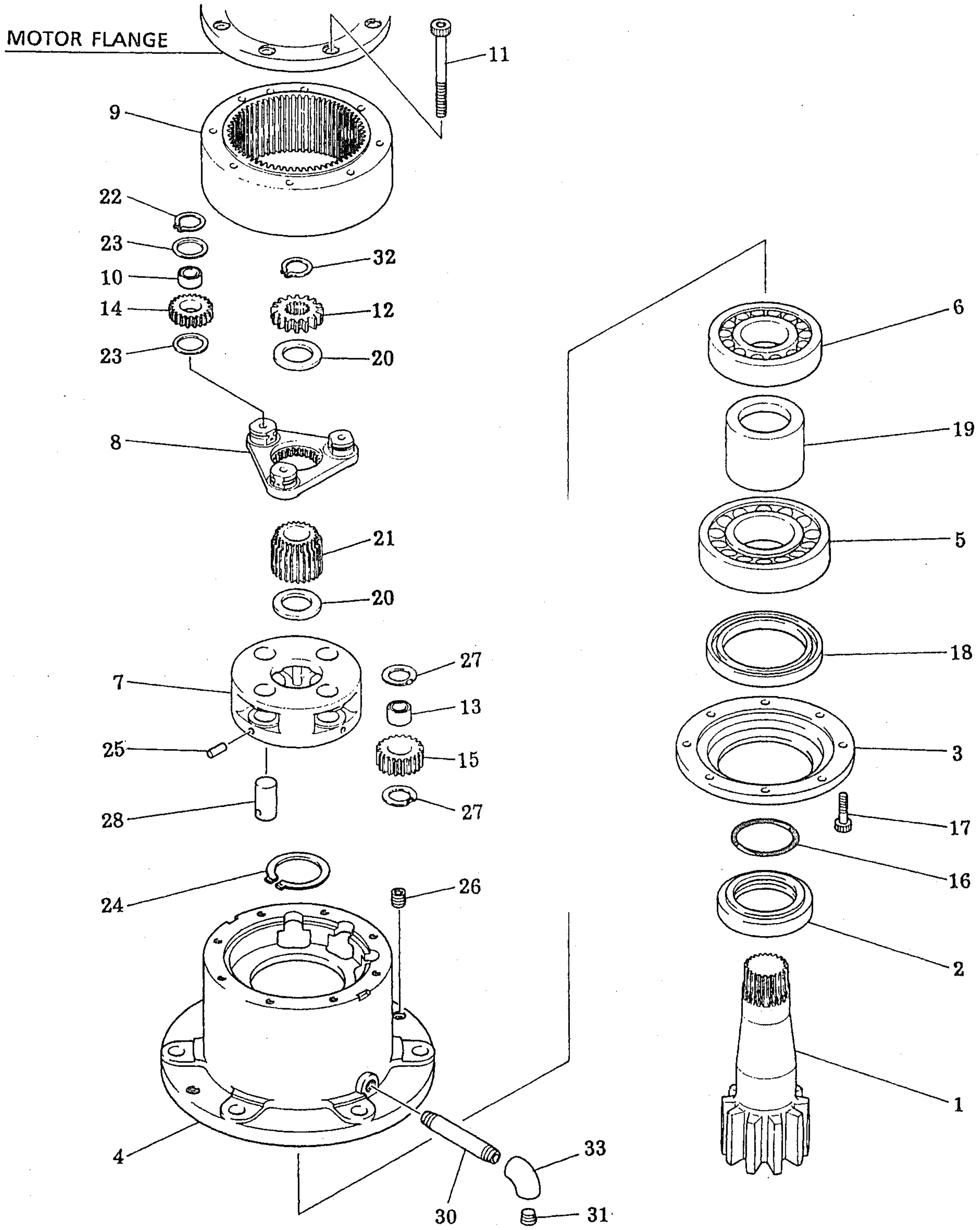
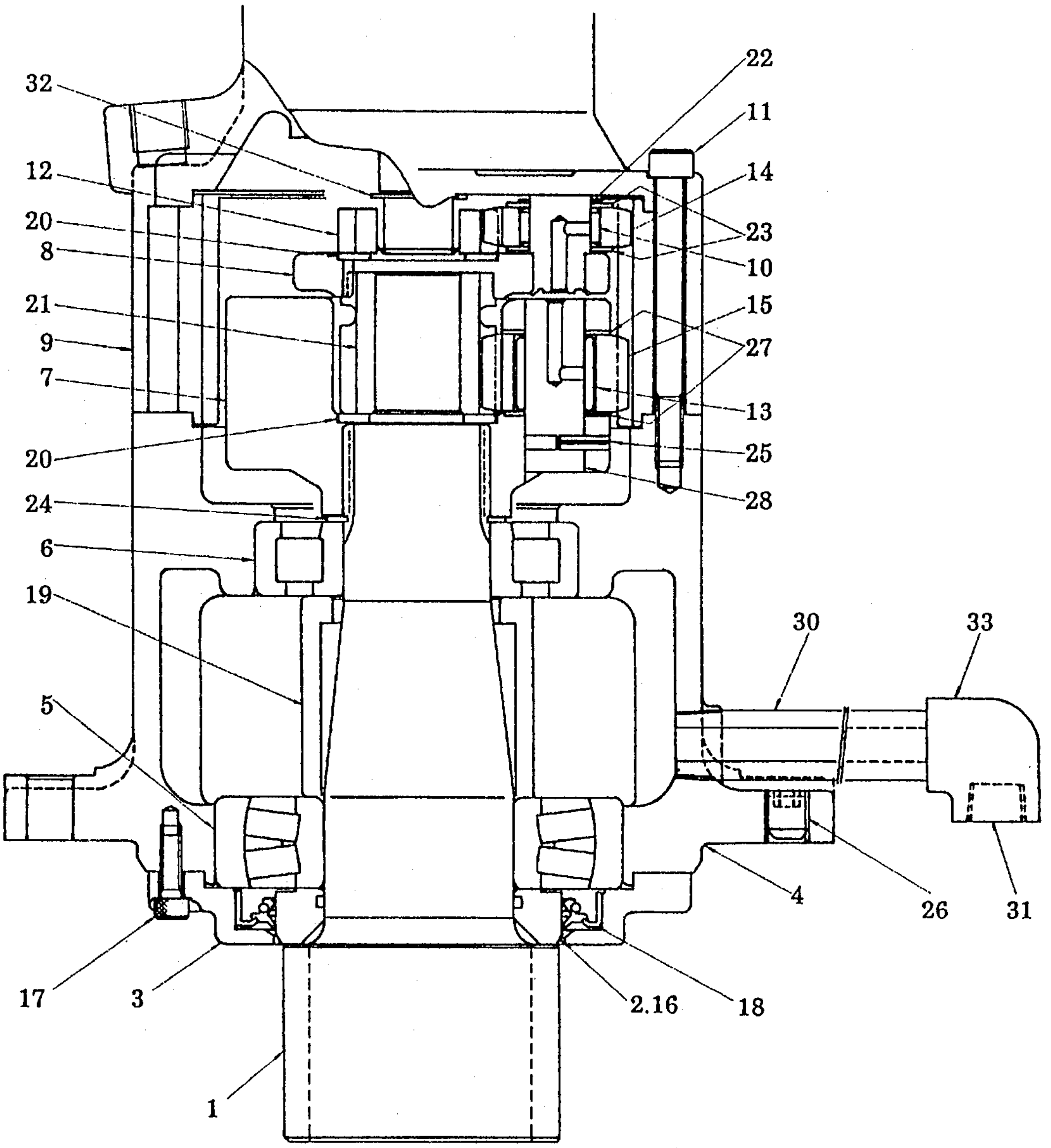

MOTOR FLANGE
11
9
22
23
10
14
23
32
12
20
8
21
20
7
25
28
27
13
15
27
24
26
4
30
33
31
6
19
5
18
3
17
16
2
1

Fig. 2


32
12
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4
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31
17
3
2.16
18
1

Fig. 3

No.	NAME	Q'ty	No.	NAME	Q'ty
1	PINION SHAFT	1	17	CAPSCREW	8
2	SLEEVE	1	18	OIL SEAL	1
3	RETAINER	1	19	SPACER	1
4	HOUSING	1	20	SPACER	2
5	ROLLER BEARING	1	21	SUN GEAR	1
6	ROLLER BEARING	1	22	SNAP RING	3
7	SPIDER	1	23	THRUST WASHER	6
8	SPIDER ASS'Y	1	24	SNAP RING	1
9	INTERNAL GEAR	1	25	SPRING PIN	4
10	NEEDLE BEARING	3	26	SET SCREW	2
11	CAPSCREW	8	27	THRUST WASHER	8
12	SUN GEAR	1	28	SHAFT	4
13	NEEDLE BEARING	4	30	PIPE	1
14	PLANETARY PINION	3	31	PLUG	1
15	PLANETARY PINION	4	32	SNAP RING	1
16	O RING	1	33	ELBOW	1

2.2 FUNCTION

The reduction unit reduces revolution transmitted from the hydraulic motor to convert it to powerful rotary force.

The planetary reduction system is employed in this reduction unit.

As shown in Fig. 4. the planetary mechanism consists of a sun gear, planetary pinions, planetary shafts, a spider and a ring gear.

When the sun gear turns, the planetary pinion is turned. Since the ring gear is fixed, the planetary shaft and the spider are rotating in one piece around the planetary pinion and the sun gear.

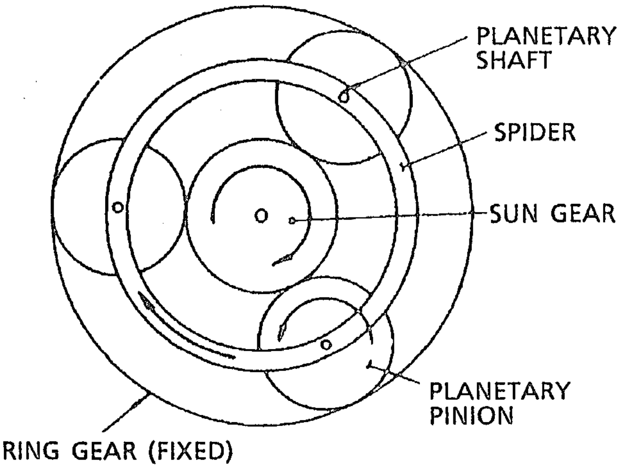

PLANETARY SHAFT
SPIDER
SUN GEAR
PLANETARY PINION
RING GEAR (FIXED)

Fig. 4

The spider supports the planetary pinions with the planetary shafts, and transmits the power from the planetary pinions to the sun gear in the next stage through the planetary shafts.

By combining this planetary mechanism in two stages, a large reduction ratio can be obtained.

As shown in Fig. 5, the inner side of the housing holds the ring gears, and the housing is fixed on the frame.

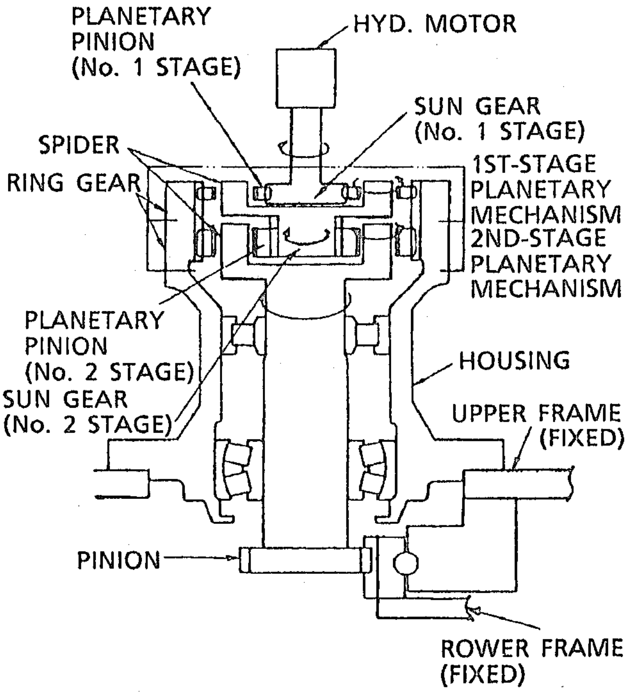

PLANETARY PINION (No. 1 STAGE)
HYD. MOTOR
SUN GEAR (No. 1 STAGE)
SPIDER
RING GEAR
1ST-STAGE PLANETARY MECHANISM
2ND-STAGE PLANETARY MECHANISM
PLANETARY PINION (No. 2 STAGE)
SUN GEAR (No. 2 STAGE)
HOUSING
UPPER FRAME (FIXED)
PINION
ROWER FRAME (FIXED)

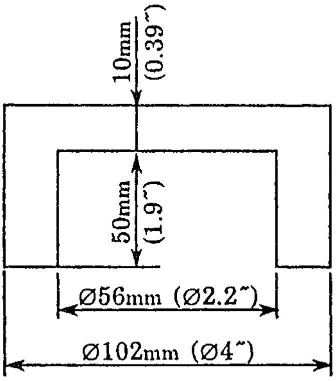
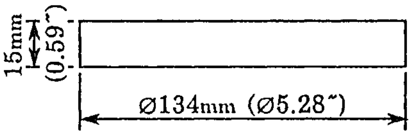
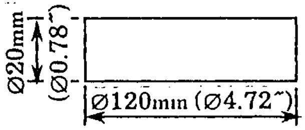
Fig. 5

3. DISASSEMBLY AND ASSEMBLY

3.1 PREPARATION

(1) Necessary tools

Table 2

Symbol	Tool Name	Remarks	
a	Metal pad (for force-fitting bearing)	Material: SS41  10mm (0.39") 50mm (1.9") Ø56mm (Ø2.2") Ø102mm (Ø4")	
b	Plier (for snap rings)	For shaft	
c	Oil seal fitting jig	Material: SS41  15mm (0.59") Ø134mm (Ø5.28")	
d	Torque wrench	10 kg · m class (72 ft-lbs class)	
e	Plastic (or wood) mallet		
f	Press	5 ton class (11000 lbs class)	
g	Bearing puller	For I.D. Ø150~200 mm (Ø6~8")	
h	Screwdriver (minus)		
i	Metal fitting	2 pcs.  Ø20mm (Ø0.78") Ø120mm (Ø4.72")	
j	General tools		
k	Three-Bond Locktite	1360K #242	1215 #515

(2) Matching mark
To facilitate the reassembly of the unit, put matching marks on the joining parts of the housing before disassembly.

(3) The numbers in parentheses correspond to the ones in construction drawings (Fig. 2, 3).

3.2 DISASSEMBLY

3.2.1 PREPARATION

(1) Remove plug (31) and drain out gear oil from the reduction unit.

(2) Before disassembly, clean the outside of the reduction unit thoroughly and check for no damage and scoring.

3.2.2 DISASSEMBLING REDUCTION UNIT ASSEMBLY

(1) Place the reduction unit ass'y on a stable work bench.

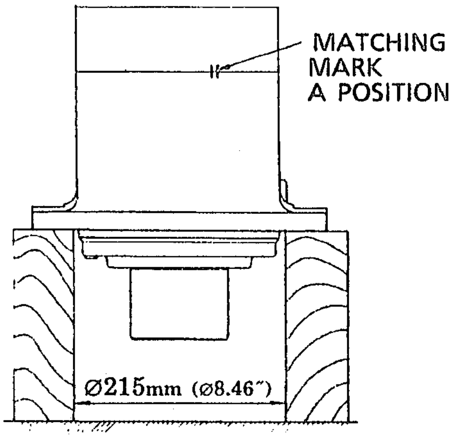


Fig. 6 Mounting to a work bench

(2) Removing internal gear (9)
After tapping the outside of the internal gear (9) lightly with a wooden hammer, by inserting a screwdriver (h) into the two indentations between internal (9) and housing (4), remove internal gear (9).

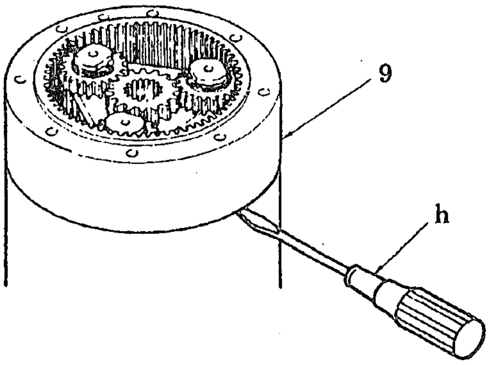


Fig. 7 Dismantling internal gear (9)

☞ If internal gear (9) cannot be removed easily from housing (4) because of three-bond (Equivalent) holding the two parts together, first remove the spider assemblies in the 1st and 2nd stages. and then remove the ring gear using a bearing puller (g).

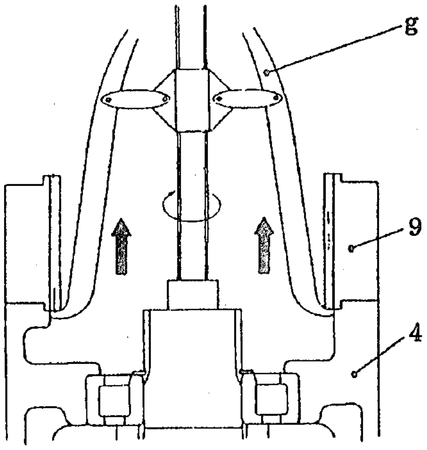


Fig. 8 How to remove the internal gear (9), using puller (g)

(3) Remove #1 sun gear (12).

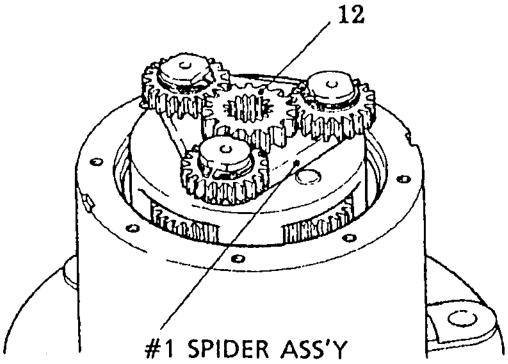


Fig. 9 Dismantling #1 spider ass'y

(4) Dismantle #1 spider ass'y (8, 14, 20, 22, 23).

(5) Remove #2 sun gear (21).

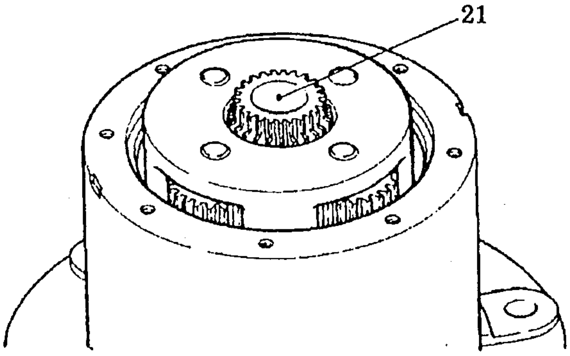


Fig. 10 Dismantling #2 sun gear (21)

(6) Dismantle #2 spider ass'y (7, 15, 20, 27, 28).

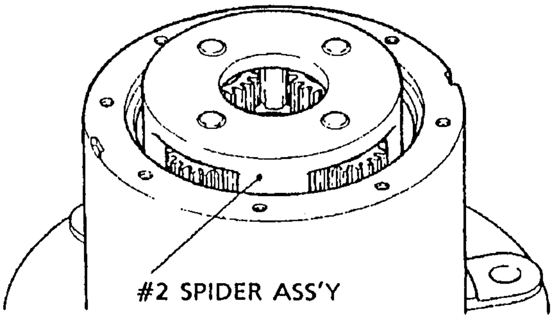


Fig. 11 Dismantling #1 spider ass'y

(7) Place retainer (3) on a stable work bench with the top of the retainer facing up, as illustrated in Fig. 12.

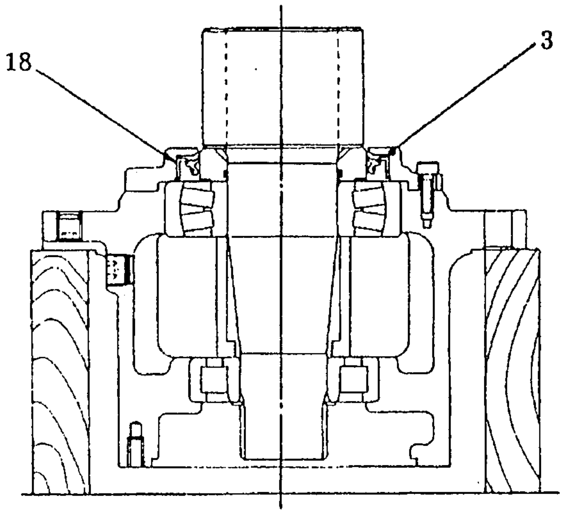


Fig. 12

(8) Removing retainer (3)

1) Loosen capscrew (17) and remove retainer (3).
2) Remove oil seal (18) from retainer (3), using a screwdriver.

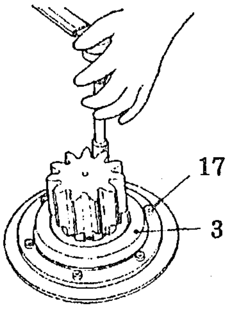


Fig. 13 Removing retainer (3)

(9) Removing the pinion ass'y

With the retainer taken off as shown in Fig. 14, draw up the pinion ass'y (1, 2, 5, 6, 16, 19, 24).

☞ The outer race of bearing (5) and the inner race of housing (4) come off smoothly if they are normal.

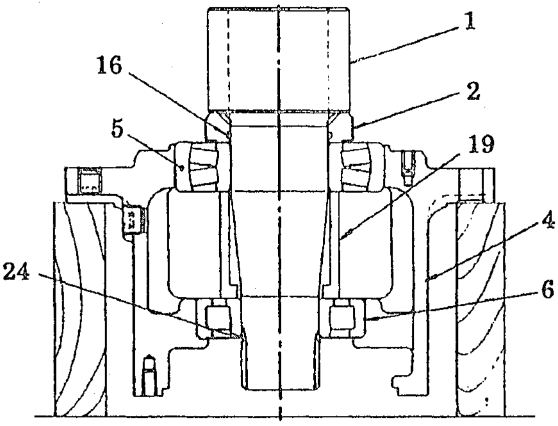


Fig. 14 Drawing out the pinion shaft by lifting it

3.2.3 DISASSEMBLING SPIDER ASSEMBLY

(1) Removing #1 planetary pinion

1) Remove snap ring (22) with a plier (b).
2) Remove thrust washer (23), planetary pinion (14), and roller needle (10).
3) Remove spacer (20).

☞ ◎ Spider (8) is caulked to the pin. For replacement, replace the spider ass'y
◎ Do not replace planetary pinion (14) singly : Always replace a set of three altogether.

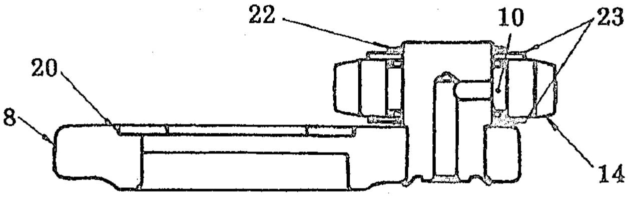


Fig. 15 Disparting #1 spider ass'y

(2) Removing #2 planetary pinion

1) Draw out spring pin (25).
2) Pull shaft (28) out of spider (7) and remove thrust washers (27) planetary pinion (15), and, roller needle (13).
3) Remove spacer (20).

☞ Do not replace planetary pinion (15) singly : Always replace a set of four altogether.

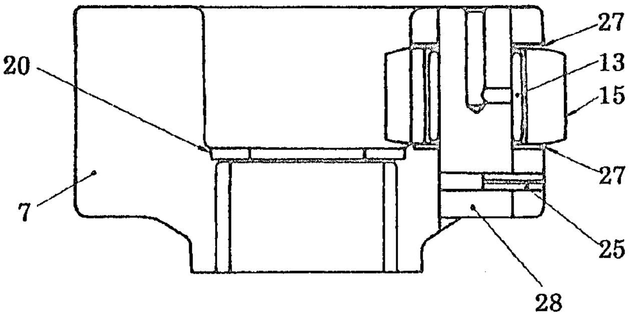


Fig. 16 Removing #2 planetary pinion

3.3.3 ASSEMBLING SPIDER ASSEMBLY

(1) Mounting #1 planetary pinion

1) Fit spacer (20) to spider (8).

2) Apply a thin film of gear oil #90 to the pinion shaft of spider (8) and the shaft of planetary pinion (14). Fix needle bearing (10), thrust washer (23) and planetary pinion (14), as shown in Fig. 21 and attach snap ring (22), by means of pliers (b).

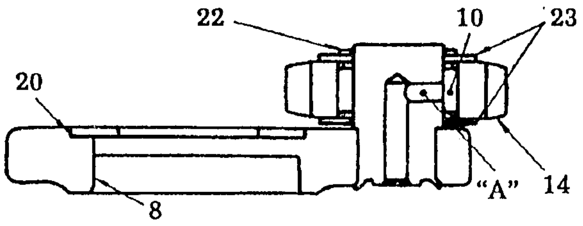
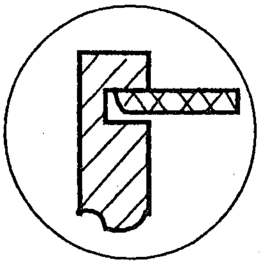


Fig. 21 Assembling #1 spider ass'y

☞ Fix the snap ring with the sharp edge on the motor side (top side).



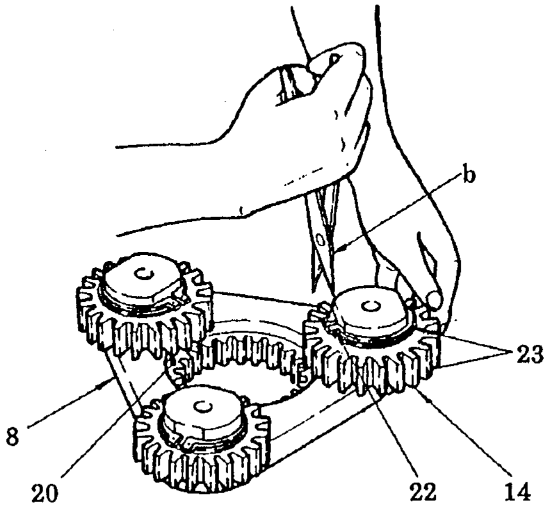


Fig. 22

(2) Installing #2 planetary pinion

1) Insert spacer (20) into spider (7).

2) Apply a thin film of gear oil #90 to spider (7), pinion shaft (28) and the bearing of planetary pinion (15), fit needle bearing (13), thrust washer (27) and planetary pinion (15) as in Fig. 23, and drive in shaft (28) and spring pin (25).

Attach shaft (28) to the hole position by matching it to spring pin (25).

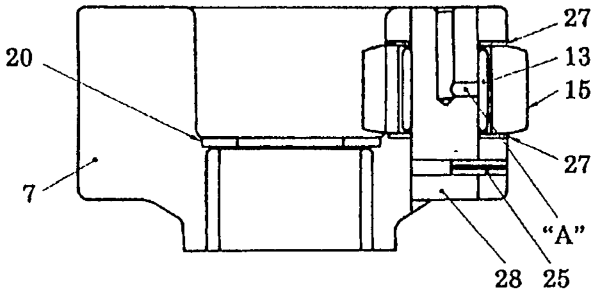


Fig. 23 Assembling #2 spider ass'y

☞ • Before assembly, make sure that the lubricating holes in the pinion shafts (9) face outward (as shown in section "A" in Fig. 22 and 24).

3.3.4 ASSEMBLING REDUCTION UNIT ASSEMBLY

(1) Place the pinion assembly (1, 2, 5, 6, 16, 19, 24) on a work table, and install the assembly in the housing (4) by lowering it slowly from above.

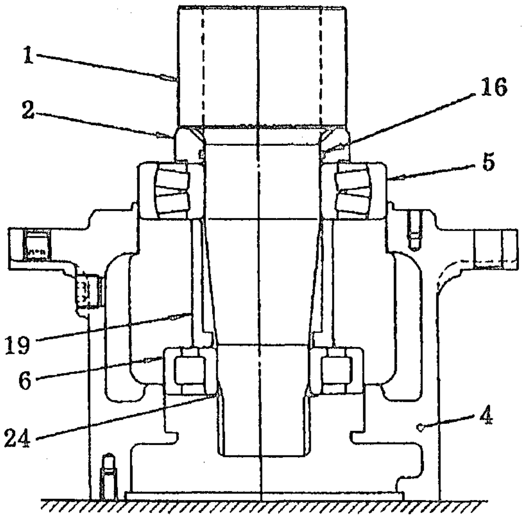


Fig. 24 Assembling pinion shaft (1)

☞ ◎ Insert the outer race of bearing (5) straight into the inner surface of housing (4).

◎ The outer race of bearing (5) can be inserted smoothly into the inner surface of the housing in normal condition. In case they can not be fitted in place, attend to the orientation of the outer race of bearing (5), exercising care so as not to damage them. Forced pressing may damage components in some cases.

(2) Fitting the retainer

1) Coat the outer surface of oil seal (18) with Three-Bond 1215 (equivalent) and press it into retainer (3), using oil seal fixing jig (c). On that occasion, do not press it in fully but leave 0.5mm (0.02in) or so of clearance to the bottom to protect the seal.

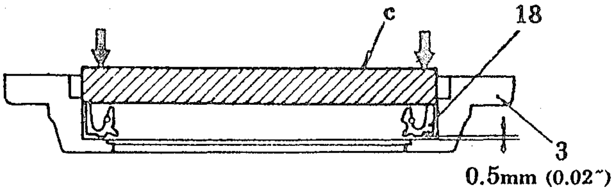


Fig. 25 Inserting oil seal (18)

☞ Fill grease to about 1/3 of the cavity between the seal lip and the dust lip of oil seal (18).

Apply a thin film of grease to the outer surface of the sleeve that comes in contact with the lip of the oil seal.

2) Tighten retainer (3) against housing by means of capscrews (17) coated with Three-Bond 1360K, to a specified torque.

Tightening torque = 3.4 ± 0.34kgf·m (24.6 ± 2.5ft · lbs).

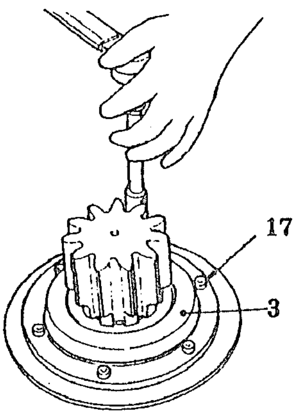


Fig. 26 Installing retainer (3)

(3) Installing #2 spider assembly

1) Place the #2 spider ass'y on a stable work bench with the spline of pinion shaft (1) facing up.

2) Insert #2 spider ass'y (7, 15, 20, 27, 28) into the spline of pinion (1).

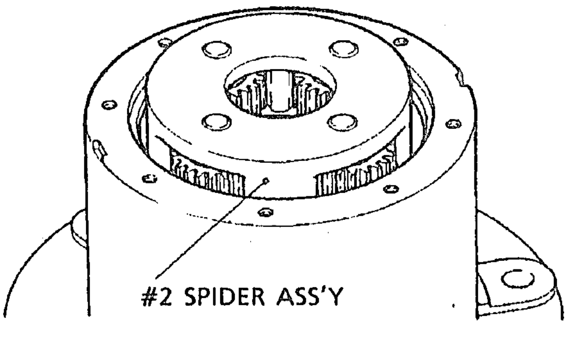


Fig. 27 Attaching #2 spider ass'y

3.2.4 DISASSEMBLING PINION ASSEMBLY

1) Take off snap ring (24), using pliers (b).
2) As shown in Fig. 18, place support metal (i) upright along the tooth groove in pinion shaft (1), receive it by sleeve (2) and draw out the pinion shaft down by means of a press.
   Press force : approx. 5ton (11000 lbs)
3) Separate O ring (16) from sleeve (2).

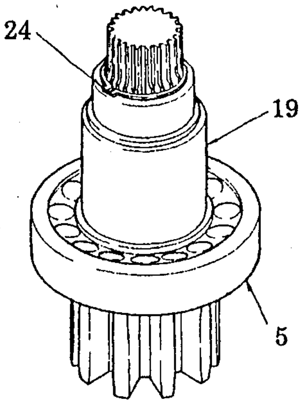


Fig. 17

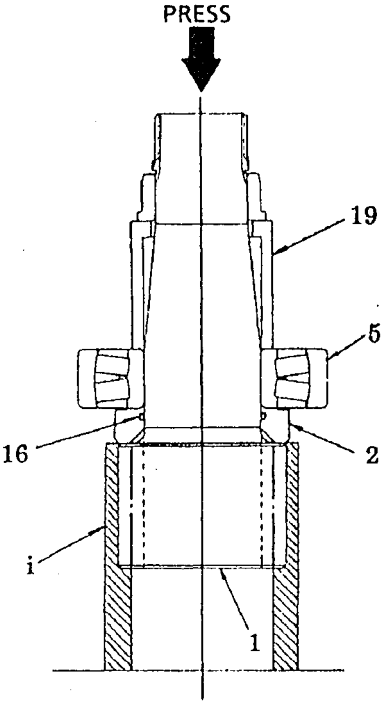


Fig. 18

3.3 INSPECTION BEFORE DISASSEMBLY

(1) Spacers and thrust washers
 1) Check for seizure and abnormal or uneven wear.
 2) Check for wear beyond the allowable values.

(2) Gears
 1) Check for any pitching or seizure on the tooth faces.
 2) Check for cracks at the base of the teeth (tooth flanks) using the dye penetrant test.

(3) Bearing
While turning, check for any abnormal sound, jamming or other abnormalities.

(4) O ring and oil seals
After disassembling, do not reuse O rings and oil seals, but replace them with new ones.

3.4 ASSEMBLY

3.4.1 PREPARATION

1) Wash parts thoroughly in cleaning oil and dry them well by jet air.
2) Check oil parts for any abnormality.

3.4.2 ASSEMBLING PINION ASSEMBLY

1) Coat O ring (16) with a thin film of grease, fit sleeve (2) and insert pinion (1).

☞ Direct the chamfered part of sleeve (2) to the gear.

2) Press in bearing (5), spacer (19) and the inner race of bearing (6) into pinion (1) all at once.
   Pressing force : approx. 4.5 ton (9900 lbs).

☞ Coat the outer circumference of the shaft of pinion shaft (1) with a thin film of gear oil to prevent seizure.

3) Fix snap ring (24).

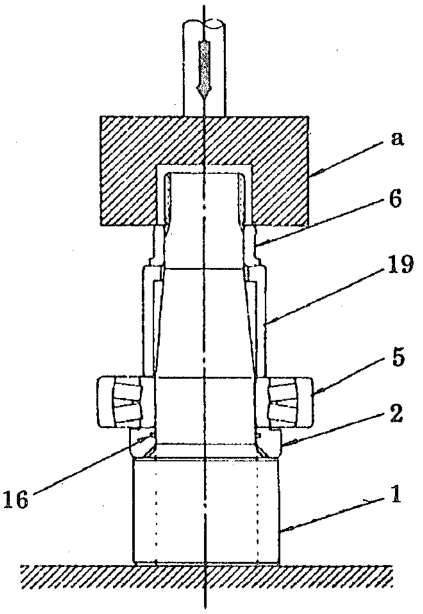


Fig. 19

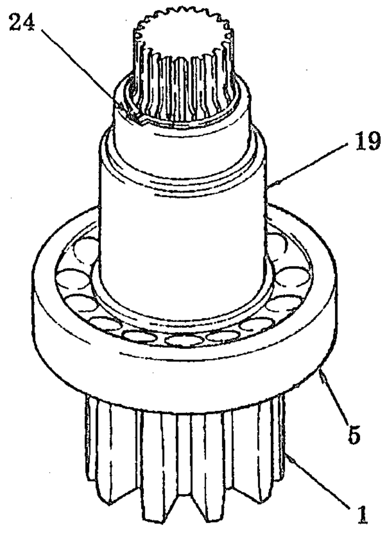


Fig. 20

(4) Install #2 sun gear (21).

☞ Install #2 sun gear (21) with the spline facing upward.

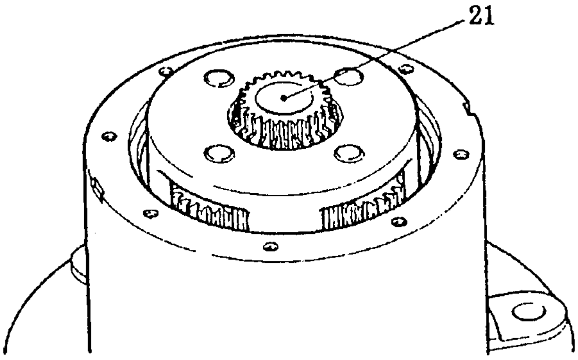


Fig. 28 Attaching #2 sun gear (21)

(5) Install #1 spider assembly (8, 14, 20, 22, 23).
(6) Install #1 sun gear (12).

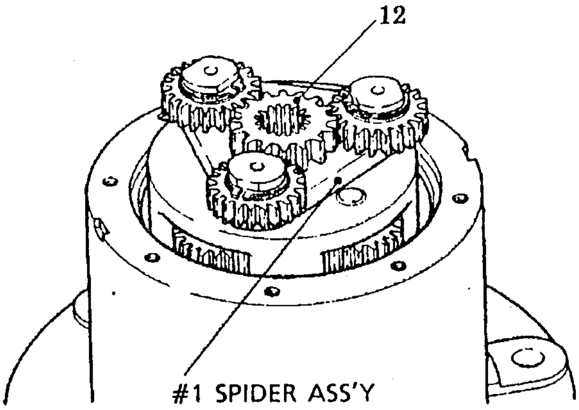


Fig. 29 Attaching #1 spider ass'y

(7) Installing internal gear (9)
1) Apply a thin film of Three-Bond 1215 (equivalent) to the matching surface of housing (4) and internal gear (9).

☞ Assembly according to the matching marks given to the mating surfaces during disassembly.

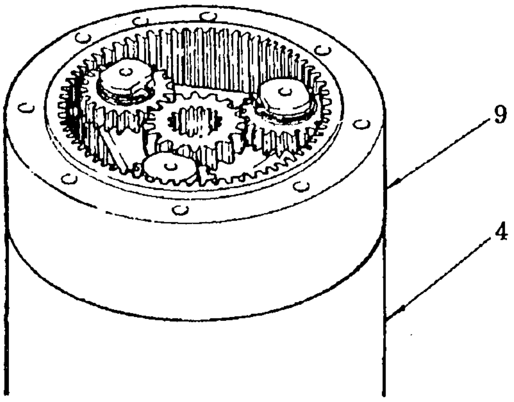


Fig. 30 Mounting internal gear (9)

3.5 INSPECTION AFTER ASSEMBLY

(1) Function
While turning #1 pinion (1), check for any abnormality.

(2) Oil leakage
Fill in engine oil API class CD SAE30 and check for oil leakage.

4. MAINTENANCE STANDARDS

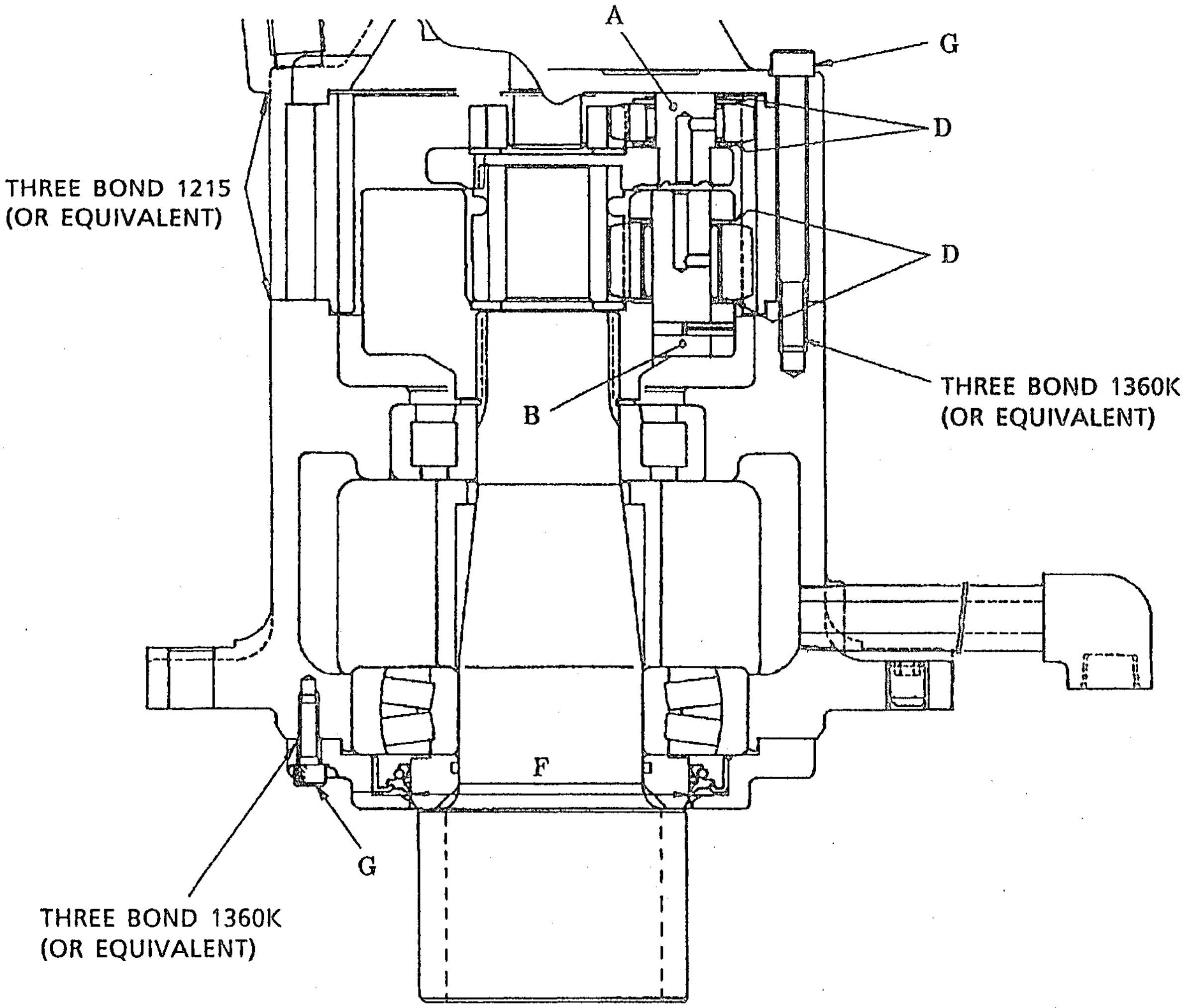


Fig. 31

Table 4

Unit: mm (in)

Symbol	Item		Standard Value	Allowable Value	Remedy
A	#1 planetary shaft		$\varnothing 23g5\,^{-0.007}_{-0.016}$ $(\varnothing 0.9055\,^{-0.0003}_{-0.0006})$	No flaking	Replace entire spider assembly.
B	#2 planetary shaft		$\varnothing 22h5\,^{0}_{-0.009}$ $(\varnothing 0.8661\,^{0}_{-0.0004})$		Replace shafts.
C	Gears	Condition of tooth face	There should be no pitching exceeding 1.6mm (0.063in)dia, abnormal wear or seizure.		Replace worn gear. (Planetary pinion should be replaced in a set of three.)
		Condition of tooth flank	There should be no cracks.		
D	Thickness of thrust washer		1.6 ±0.1 (0.063 ±0.004)	1.4 (0.055)	Replace worn thrust washer.
E	Thickness of worn spacer		$3.0\,^{0}_{-0.1}$ $(0.118\,^{0}_{-0.004})$	2.5 (0.098)	Replace worn spacer.
F	Wear in sleeve (Diameter of part coming in contact with oil seal)		$\varnothing 105\,^{0}_{-0.054}$ $(\varnothing 4.1339\,^{0}_{-0.0021})$	Ø104.5 (Ø4.114)	Replace worn sleeve.
G	Tightening torque of capscrew		M8··· 3.4±0.35kgf·m(24.6±2.5ft·lbs) M10····6.7±0.7kgf·m 48.4±5.1ft·lbs)		